भाकृअनुप
ICAR

Annual Report
2019

भारतीय गन्ना अनुसंधान संस्थान, लखनऊ
ISO 9001:2015

ICAR-INDIAN INSTITUTE OF SUGARCANE RESEARCH, LUCKNOW

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From the Director's Desk

The country's sugarcane production in the sugarcane season 2019-20 has remained above 350 million tonnes for the third consecutive year in a row . The sub-tropical state Uttar Pradesh too performed better in this front by producing around 225 million tonnes of sugarcane with higher productivity level of 80.5 t/ha compared to that of national level of 78.2 t/ha during 2018-19. ICAR-IISR, Lucknow through its research and development efforts and through collaborations with public and private organizations in vital areas of sugarcane production such as healthy seed canes, improved package of practices, better insect pests and disease management and mechanization has contributed to increase the sub-tropical sugarcane productivity in India and especially in Uttar Pradesh. It is a privilege to lead a glorious Institute like ICAR-IISR, Lucknow which has associated itself in making new records of this sort and in the service of the nation. It gives me immense pleasure to share the yearly research highlights in the form of Annual Report of the Institute for the year 2019.

Under crop improvement research, two sugarcane varieties *i.e.* CoLk 12207 (*Ikshu*-6; an early) and CoLk 12209 (*Ikshu*-7; a mid-late) were released and notified for commercial cultivation in North Central and North Eastern Zones of India. Three early maturing sugarcane clones *i.e.* CoLk 19201 (LG 12429), CoLk 19202 (LG 12040) and CoLk 19203 (LG 11067) and one mid-late maturing clone CoLk 19204 (LG 10723) were accepted for AICRP (S) multi-location testing in North West Zone of India. The Institute also contributed three high sugar genetic stocks to National Hybridization Garden (NHG) at ICAR-SBI, Coimbatore. In addition to basic research work, the biotechnological interventions were focussed on profiling and prediction of small RNA transcriptomes in red rot affected sugarcane, multiplication of new sugarcane varieties through *in-vitro* cultures and testing of varieties for genetic fidelity.

Under crop production research, a highly profitable integrated farming system involving autumn planted sugarcane at 120 cm row spacing with garlic in 1:5 ratio with a yield level of sugarcane 140.48 tonnes per hectare and resulting in income earning to farmers at ₹ 7.72 lakh per ha on 2018-19 prices. The Institute research efforts on drip fertigation, crop residue management and assessment of nutrient status and soil quality in sugarcane intensive areas are also continuing. Around 43 sugarcane genotypes were evaluated for their reaction against red rot and wilt disease under crop protection research programme. Number of insect pests and diseases surveys was conducted in command areas of sugar mills in Uttar Pradesh, Bihar and Madhya Pradesh. Thirty eight sugarcane genotypes evaluated for reaction against major insect pests.

Under plant physiology and biochemistry research, the sugarcane varieties were evaluated for post-harvest deterioration of cane quality in late (May/June) harvested sugarcane which varied from 20.7% to 37.8% deterioration in terms of sucrose % in juice and minimized to 2.1 to 6.6% with the use of chemicals. Using biotechnological approaches, a genome of a virulent pathotype (cf 08) of *Colletotricum falcatum* causing red rot to sugarcane was sequenced and raw reads were submitted at NCBI. The work on different classes of genes of red rot pathogen and their role in plant pathogen interaction is continuing. Under agricultural engineering research, two row disc type ratoon

management device with and without stubble shaving attachment was demonstrated at 34 farmers' fields under Biswan sugar mill command areas in Central U.P.

Number of sugarcane extension activities were carried out at the Institute, its regional centres at Motipur (Bihar) and Pravaranagar (Maharashtra) and through Institute's two KVKs at Lucknow and in the most sugarcane intensive Lakhimpur Kheri (Uttar Pradesh). For fast spread of newly released cane varieties, 30 FLDs on seed cane production technology were conducted in farmers' fields in Sitapur, Lakhimpur Kheri and Hardoi districts of Uttar Pradesh. For capacity building of development personnel and farmers, several training programmes, *goshthies,* meetings and field visits were also conducted in Uttar Pradesh, Bihar and Maharashtra. Socio-economic research on sugar beet cultivation revealed that returns from its cultivation were more than double the returns obtained from rice and wheat cultivation in Punjab. A web based application AICRP Reporter also developed to provide an effective data recording and reporting platform for AICRP on Sugarcane.

The overall annual growth of the Institute was possible with the guidance, encouragement and continuous support received from Dr. T. Mohapatra, Secretary, DARE & DG, ICAR; Dr. A.K. Singh, DDG (CS & Horti.) and Dr. R.K. Singh, ADG (CC), ICAR, which I acknowledge with sincere gratitude and reverence. I appreciate the efforts of all the Heads of Divisions, Drs. Maharam Singh, Radha Jain, D.R. Malaviya, S.K. Shukla and A.K. Singh and In-charges for timely submission of research outcome. I am thankful to the members of Publication Committee, Drs. Sangeeta Srivastava, L.S. Gangwar, A.K. Sharma and Mr. Brahm Prakash for their praiseworthy efforts in bringing out the Report in time. Last but not the least, I am thankful to all the staff who supported and contributed to the yearly progress of Institute.

Date : January 29, 2020

(A.D. Pathak)
Director

Contents

Executive Summary

Crop Improvement

- Two sugarcane varieties *i.e.* CoLk 12207 (*Ikshu*-6; early maturity group) and CoLk 12209 (*Ikshu*-7; mid-late maturity group) were released and notified by CVRC for commercial cultivation in North Central and North Eastern Zones of India.
- Three early maturing sugarcane clones *i.e.* CoLk 19201 (LG 12429), CoLk 19202 (LG 12040) and CoLk 19203 (LG 11067) and one midlate maturing clone CoLk 19204 (LG 10723) were accepted during the AICRP(S) Annual Group Meeting held at UAS, Dharwad during 2019 for multi-location testing in North West Zone of India.
- Two sugarcane varieties namely, CoLk 11203 (*Ikshu*-5) and CoLk 11206 (*Ikshu*-4) were applied for registration under the PPV & FRA.
- A collection of 350 genotypes consisting of *Saccharum officinarum*, *S. barberi*, *S. sinense*, ISH clones, Ikshu ISH clones, LG selections, commercial hybrids, and somaclonal variants (25) is being maintained.
- Three high sugar genetic stocks, *viz.*, LG 14482, LG 14564 and LG 11440 with sucrose % in juice values 19-20% during January, were sent to National Hybridization Garden at ICAR-SBI, Coimbatore.
- High-quality reads from small RNA libraries of sugarcane varieties BO 91 and CoJ 64 (red rot resistant and susceptible, respectively) inoculated with *C. falcatum* (Cf 08) predicted more than 300 known miRNA (in each sample) and 472 novel miRNA based on hairpin structure of the small RNA precursor having 12,566 target genes associated mostly with cellular and metabolic processes, cell or organellar development and some with disease resistance mechanism.
- *In vitro* cultures of new sugarcane varieties CoLk 12207 and CoLk 12209 were established and multiplied through enhanced auxiliary shoot proliferation using apical shoot explants.
- A protocol for *in vitro* conservation of sugarcane genotype *Khakai* using slow-growth culture technique has been developed which involved establishment of shoot-tip cultures, followed by their multiplication on MS medium with 2.22 µM BA, 0.5 µM Kinetin, 0.5µM GA_3. The slow-growth culture regime included maintenance of cultures at 25^0C on MS medium supplemented with 2.22 µM BA, 0.5 µM Kinetin, 0.5µM GA_3, 5% sucrose and 5.0 µM flurprimidol. Successful shoot multiplication without any genetic variation in the recovered cultures was recorded from stored slow-growing shoots incubated for 360 days.
- A total of 2512 samples (530 samples of sugarcane and 1982 samples of banana) out of 7176 samples from tissue culture production facilities were tested for mother stock virus indexing.
- DUS characters were recorded on 125 varieties in reference collection of 153 varieties as per the testing guidelines.
- One hundred twenty two germplasm of sugarbeet was maintained during 2019-20 at Lucknow, out of which 80 germplasm were planted at Mukteshwar for seed production.
- Thirteen varieties showed high superiority in terms of single root weight under drought conditions.

Crop Production

- The average soil pH values of Khatauli sugar mill command areas are slightly alkaline in nature (8.07) but EC values falls under normal range. The nutrient index value of SOC and available nitrogen falls under low categories whereas available P, K and S index values falls under medium categories. The nutrient index of Zn falls under medium categories whereas nutrient indices of Cu, Fe and Mn come under higher categories as NI was observed >2.33.
- The split application of NPK under drip fertigation found significantly superior over farmers practice. The increase in growth parameters were associated with splitting of N fertilizer than P and K. Splitting of NPK further improved different growth attributes in ratoon sugarcane crop.
- Crop residue management treatment recorded increase in tiller production in sugarcane by 9.44% over without crop residue management. In other crops, rice yield was recorded 11.13% higher with brown manuring over that without brown manuring and 10.48 & 18.00% higher wheat yield was recorded with conventional and zero tillage, respectively with crop residue over conventional tillage.
- Germination, number of tillers, plant height was observed high in sett treatment by biostimulator @ 2.5 ml/litre of water

- Effectiveness of various microbial cultures in increasing the ratoon cane productivity and on soil quality parameters in multi ratooing system was studied and microbial culture of different nutrients was isolated, characterized and identified for compatibility. These microbial cultures are for N- *Gluconacetobacter sacchari*, P – *Pseudomonas flouresens*, K - *Enterobacter cloacae*, Zn - *Acinetobacter calcoaceticus and* S - *Pseudomonas nitroreducens.*
- Higher number of tillers and shoot population was recorded under treatment of sugarcane at 150 cm row spacing + garlic intercropping (149.63 thousand /ha at 90 days after planting- DAP), shoot count (137.41 thousand/ha at 120 DAP) than sugarcane sole (90 cm row spacing) the conventional planting (125.18 thousand /ha at 90 DAP and 112.04 thousand/ha at 120 DAP, respectively). Autumn sugarcane at 120 cm row spacing+garlic (1:5 ratio) produced maximum yield (140.48 q/ha) and fetched the net income of ₹ 7.72 lakh/ha.
- Sugarcane in spring intercropping systems also hold promise in increasing net income as compared to sole sugarcane. The integrated farming systems (IFS) *i.e.* Sugarcane (0.8 ha) + Vegetable (0.2) + Backyard poultry + Fisheries system was observed to the best combinations as far as generation of farm income is concerned.
- Among three component crops (Rice, *Tulsi* and *Kalmegh*) evaluated as per treatments in the field conditions, *Tulsi* recorded the highest productivity during *Kharif* season. Further, as per treatments, the succeeding crops *i.e. Ishabgol, Stevia, Ashwagandha*, wild marigold and autumn sugarcane were planted in the field during *rabi* season 2019-20.
- Shoot and root dry matter accumulation increased significantly with increasing density of *Ipomoea* spp. per pot.

Crop Protection

- Insect pests and disease surveys were conducted in command areas of sugar mills in Uttar Pradesh, Bihar and Madhya Pradesh. Severe incidence of *Pyrilla perpusilla* was recorded in Narsinghpur district of the state. Abundance of *Epiricania melaleuca* was also observed in area.
- Three strains of *Trichoderma viz.*, STr-64, STr-83 and STr-126 were found promising for suppressing red rot infection and enhancing germination and cane yield when applied as sett dip in 106 spores/ml suspensions before planting and soil application (sole) and with fertilizers.
- Serial thermotherapy (MHAT at 50°C for two hours) for three consecutive days and standard practice of MHAT were effective against YLD.
- Red rot designated pathotypes of sub-tropical zone have been deposited to National Bureau of Agriculturally Important Microorganism, Mau and NCBI, USA.
- Positive correlation of soil Arthropods abundance with SOC was observed.
- A black beetle, *Heteronychus* sp., belongs to sub family *Dynastinae* of *Scarabaeidae* family of *Coloeoptera*, the family of white grubs. Adult of *Heteronychus* sp. damage the cane.

Plant Physiology and Biochemistry

- Maximum deterioration (after 11 days) when cane are harvested late in months of May/ June, in terms of sucrose % juice was observed in CoLk 09204 (39.8%) and minimum in CoPK 05191 (20.7%) variety. Though chemical formulation (BKC+SMS) has reduced the level of cane deterioration even in cane harvested late in month of May/June, its impact was only 2.1 to 6.6% among three early maturing varieties namely CoLk 94184, CoPK 05191 and Co 0238. Delayed crushing has significantly decreased the cane weight which ranged from 23 to 32% among four (CoLk 94184, CoLk 09204, CoPK 05191 and Co 0238) varieties (11 days of post harvest).
- When a chemical formulation was applied on over-stand cane, deterioration in cane quality was in general observed less in treated canes in terms of sucrose % juice over control. Most responsive variety to formulation was CoPk 05191 wherein deterioration was almost 3.2% less than those of control. Brix % increased in almost all four (CoLk 94184, CoLk 09204, CoPk 05191 and Co 0238) varieties when these varieties were left in field beyond May.
- Genome of a virulent pathotype (*Cf* 08) of *C. falcatum* causing red rot to sugarcane was sequenced and raw reads has been submitted at NCBI under Bioproject PRJNA509540. After assembly, a total of 238 contigs were observed and submitted as SWKJ00000000 at NCBI. A total of 18,635 protein-coding genes were predicted.
- Functional annotation of red rot pathogen genome revealed different classes of genes having important role in plant-pathogen interaction. The genome sequences were compared with other fungal species which revealed that *C. falcatum* is closely related to *C. graminicola* and *C. sublineola* the causal organisms of anthracnose in maize and sorghum.

Agricultural Engineering

- Two row disc type ratoon management device was developed. The other prototype having stubble shaver attachments performs stubble shaving along with off barring and fertilizer application. Prototype without stubble shaver is suitable for piecemeal harvesting. Effective field capacity of the machine was 0.35-0.40 ha/h.
- Prototype of developed multipurpose tool frame with furrow opening attachment was demonstrated at farmers' field in 1.0 ha area in Biswa Sugar mill area for furrow opening for planting of sugarcane using IISR deep furrower. Trapezoidal furrows were formed having top width of 32 cm and bottom width of 18 cm. The depth of furrow opened was observed 22-25 cm as compared to conventional ridger where only 10-12 cm depth of furrows was achieved. The field capacity of the machine was 0.26 ha/h with field efficiency of 70%.
- The IISR multipurpose tool frame with interculturing attachment was also demonstrated at farmers' field in different villages of Biswan Sugar mill area for interculturing operation in sugarcane crop. Machine tines/shovel was adjusted as per the crop spacing. The machine was used in more than 20 hectare area at 34 farmer's field for inter-row interculturing operation. Machine was used for interculturing after 50-60 days of planting. The machine has a provision of operation in combination mode for inter row interculturing, intra-row herbicide spraying and fertilizer application in a single pass.
- Prototype of manual cane node cutter was developed for cutting of cane nodes from whole seed cane. It was field tested at IISR farm. 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 of the machine. Metering mechanism, comprising of lugged ground wheel driven belt and mild steel L shape cells, performed satisfactorily. Effective field capacity of the planter was 0.15-0.18 ha/h.
- Manual multicrop planter was tested at farmer's field in Biswa Sugar mill area of Sitapur district for sowing of chickpea, lentil and peas as intercrop in sugarcane which were planted at row spacing of 90 cm with IISR sugarcane cutter planter. The effective field capacity of the machine was 0.10-0.11 ha/h with field efficiency of 63-65%.
- Testing of the prototypes of manual stripper cum detopper is under progress.
- Modifications were carried out in already developed prototype of manual weed cleaner by changing its main pipe.
- A prototype of solar powered manual sprayer was developed for spraying herbicide/fungicide in various crops. Preliminary testing of this sprayer has been carried out at Institute farm for spraying pre-emergence herbicide.
- A sugarcane cleaner cum washer for jaggery was refined and being evaluated.
- Scaling up of existing IISR 2-pan furnace was carried out.
- Design and development of integrated dryig system for jaggery drying is under progress.

Statistics, Economics and ICT

- Studies on the impact of sugarcane cutter planter were conducted. The extent of cost reduction in sugarcane cultivation was worked out to the extent of ₹ 182 crores, annually with the use of this machine.
- Sugarcane farmers in Maharashtra faced challenges of drought and flood extreme climates, water scarcity and incidence of disease, insects-pest (White grab). The cost of sugarcane production and its processing has enhanced both for farmers and sugar mills. The average cane price paid to the farmers was ₹ 3,032 per tonne in Maharashtra.
- The average cost of sugar production in Maharashtra varies from ₹ 2,953 to ₹ 3,657/ quintal with ex-mill sugar price ₹ 32-34 per kg in stand alone, integrated sugar-energy complex. The cost of sugarcane and conversion cost accounts for 80 and 20%, respectively.
- The Government announced the flexi price policy for bio-ethanol processed from different raw materials to enhance its supply for achieving 10% EBP targets. India has achieved 6.5% EBP targets. The price for bio-ethanol produced from B-heavy molasses and directly from sugarcane juice was ₹ 54.27 and ₹ 59.48 per litre, respectively.
- Bioethanol production from B-heavy molasses gives income of ₹ 15.29 per litre to the distillery as compared to ₹ 12.68 per litre by final C-molasses. However, bioethanol produced from sugarcane juice gives net income of ₹ 5.69 per litre.
- A web based application, AICRP Reporter, has been developed to provide an effective data recording and reporting platform for AICRP on Sugarcane.

- Analysis of 25 years data on cane yield and CCS (t/ha) of newly developed varieties under AICRP on Sugarcane reveals that the overall genetic improvement in terms of CCS (t/ha) was found progressive as it was reported in cane yield in all the four sugarcane zones during 1991 to 2015, *i.e.* 4.28% during 1991 to 2000, 13.11% during 2001 to 2010 and 10.59 % during 2011 to 2015 over the base period 1989 to 1990. The overall improvement in CCS (t/ha) was found from 9.08 to 10.59 (t/ha) in the country during twenty five years. The genetic improvement in CCS (t/ha) was 46.81% in East Coast Zone during 1989 to 2015, followed by North West Zone (35.21%) and Peninsular Zone (14.93%).

Extension and Training Unit

- A total of 35 seed cane plots in 20 ha area were maintained in the fields of 30 farmers for encouraging entrepreneurship development for sugarcane seed production and multiplication. An increase of 60.16% was recorded in Achievement Motivation attribute of Entrepreneurial Behaviour of the farmers. In addition, thirty FLDs on seed cane production technology were also conducted in farmers' fields in Sitapur, Lakhimpur, Hardoi districts of Uttar Pradesh.
- Public-Private-Farmer Partnership (PPFP) model has been developed and promoted in four sugar mills command area of DCM Sugar in Central Uttar Pradesh.
- Results on PGR technology assessed in farmer's field revealed that germination (%) of cane and initial shoot population at 45 days after planting in treated plots recorded an increase of 38.1% and 30.4%, respectively.
- Five Skill Development Residential Trainings were organized for students and sugarcane development officials. Five field days were organized in Sitapur, Lakhimpur Kheri, Barabanki and Ballia districts of Uttar Pradesh. Several residential and off campus training programmes were conducted in which more than 200 participants were trained.

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 culture as well as to co-ordinate research work done on this crop in different states of the country. The Government of India took over the Institute from the Indian Central Sugarcane Committee on January 1, 1954, and thereafter, it was transferred to the Indian Council of Agricultural Research (ICAR), New Delhi on April 1, 1969. The Institute is located in Lucknow, the capital city of Uttar Pradesh and 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 at:

Issues

- Low levels of cane yield and sugar recovery
- 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

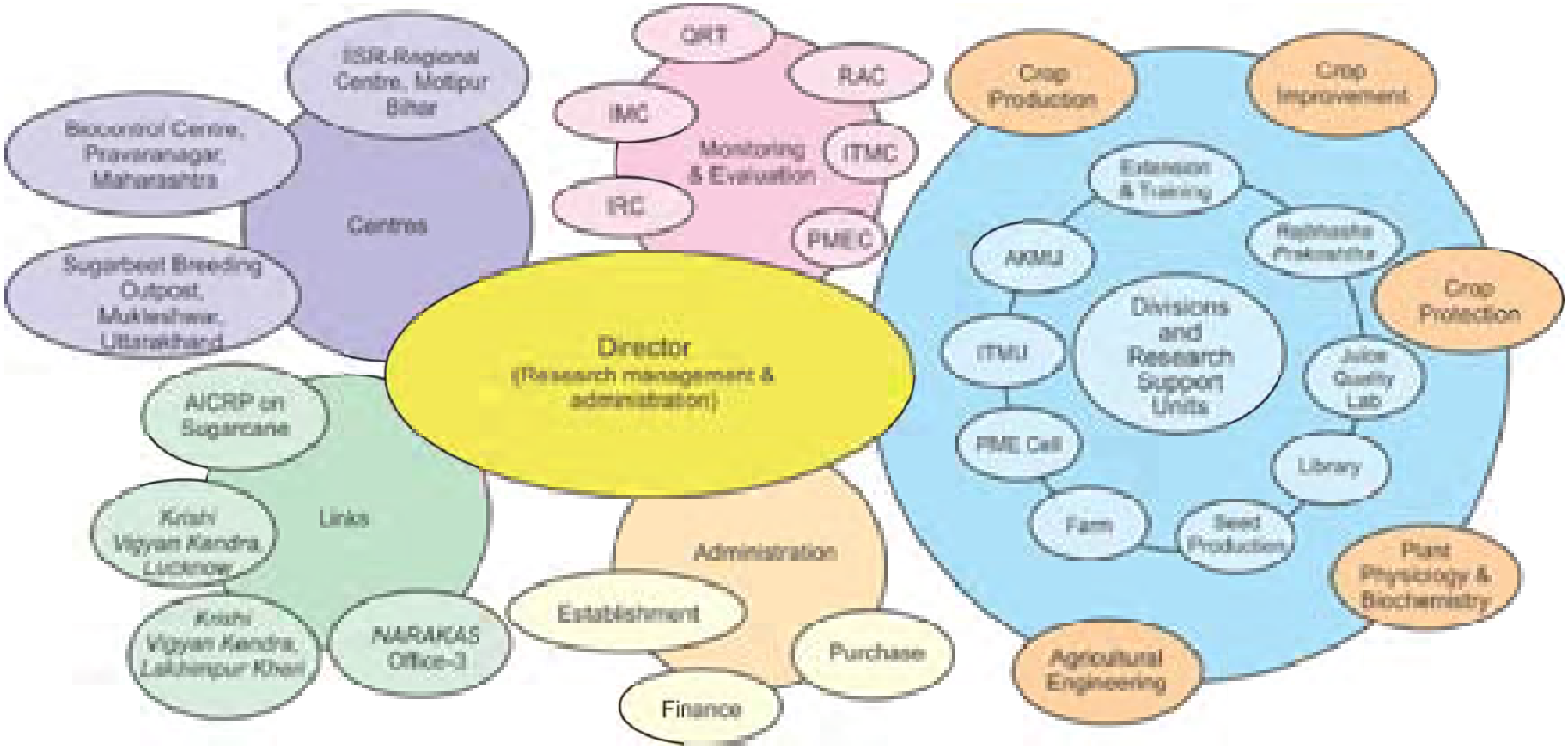
d. Reducing cost of pesticide use in an eco-friendly manner through bio-intensive IPM and IDM

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

(as on December 31, 2019)

Particulars	Plan (₹ in lakh)	
	Revised Estimate	Expenditure
ICAR-Indian Institute of Sugarcane Research	7503.38	5570.40
All India Coordinated Research Project on Sugarcane	940.82	752.65

Staff Position

(as on December 31, 2019)

Category	Sanctioned	Filled	Vacant
Research Management Position	1	1	0
Scientific			
Principal Scientist	6	2	4
Senior Scientist	14	14	0
Scientist	52	44	8
Total	**73**	**61**	**12**
Technical			
Category-I	77	37	40
Category-II	54	32	22
Category-III	3	2	1
Total	**134**	**71**	**63**
Administrative	48	38	10
Skilled Supporting Staff	36	11	25
Grand Total	**291**	**181**	**110**

CHAPTER 1

Genetic Improvement of Sugarcane for Higher Cane and Sugar Productivity

Technology development

Release of sugarcane varieties

Two sugarcane varieties *i.e.* CoLk 12207 (*Ikshu*-6; early maturity group) and CoLk 12209 (*Ikshu*-7; mid-late maturity group) were released and notified by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties for commercial cultivation in North Central and North Eastern Zones of India vide the Gazette of India Notification No. S.O. 1498 (E) dated the April 0l, 2019. Some key features and attributes of the two varieties are mentioned in Table 1.1.

Sugarcane clones accepted for multi-location testing

Three early maturing sugarcane clones *i.e.* CoLk 19201 (LG 12429), CoLk 19202 (LG 12040) and CoLk 19203 (LG 11067) and one midlate maturing clone CoLk 19204 (LG 10723) were accepted during the AICRP(S) Annual Group Meeting held at UAS, Dharwad during 2019 for multi-location testing in North West Zone of India (Table 1.2).

Registration of sugarcane varieties

Registration of two sugarcane varieties namely,

Table 1.1. Salient features of newly released and notified sugarcane varieties CoLk 12207 (*Ikshu-6*) and CoLk 12209 (*Ikshu-7*)

Variety	Parentage	Maturity group	Cane yield (t/ha)	CCS yield (t/ha)	Sucrose % at harvest	Pol % cane at harvest
CoLk 12207 (*Ikshu*-6)	CoLk 8002 GC	Early	75.42	8.74	16.90	13.17
CoLk 12209 (*Ikshu*-7)	LG 95053 × CoPant 90223	Mid-late	77.50	9.38	17.66	14.33

Fig. 1.1. Field view of the plants and buds of CoLk 12207

Fig. 1.2. Field view of the plants and buds of CoLk 12209

Table 1.2. Salient features of the sugarcane clones accepted for multi-location testing under AICRP on Sugarcane

Clone	Parentage	Maturity group	Cane yield (t/ha)	CCS yield (t/ha)	Sucrose % at harvest	Red rot rating
LG 12429 (CoLk 19201)	LG 97050 GC	Early	89.08	12.06	19.50	MR
LG 12040 (CoLk 19202)	CoJ 99192 × CoSe 92423	Early	88.16	11.40	18.74	MR
LG 11067 (CoLk 19203)	CoJ 99192 × CoS 8436	Early	81.92	11.23	19.57	MR
LG 10723 (CoLk 19204)	CoS 8436 × CoSe 92423	Midlate	102.62	13.68	19.05	MR

CoLk 11203 (*Ikshu*-5) and CoLk 11206 (*Ikshu*-4) was taken up under the Protection of Plant Variety and Farmers Right Act, 2001 for their protection. The duly filled applications of aforesaid varieties have been submitted to the Protection of Plant Variety and Farmers Right Authority, New Delhi.

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

A collection of 350 genotypes consisting of *Saccharum officinarum*, *S. barberi*, *S. sinense*, ISH clones, Ikshu ISH clones, LG selections, commercial hybrids, and somaclonal variants (25) was maintained and the required material was supplied to various on-going projects of the Institute. The collection includes 173 commercial hybrids, 51 ISH & Ikshu ISH lines, 71 LG clones and 30 species level genotypes. A 'Varietal Cafeteria' comprising of 28 early and mid-late maturing varieties was planted in March, 2019 to provide an opportunity for farmers to select varieties of their choice. The LG and CoLk clones available to the Breeders under NHG, ICAR-SBI, Coimbatore were multiplied and included in the germplasm collection.

Development of sugarcane varieties for sub-tropics

Hybridization and seedling raising

A total of 29 bi-parental sugarcane crosses were attempted at National Hybridization Garden, ICAR-SBI, Coimbatore during the crossing season of 2019. In addition to this, eight poly crosses, five selfs and 50 GCs were also effected. The fluff of these crosses will be sown in the glass/poly house for the seedling raising. Approximately 25,000 seedlings derived from 27 biparental crosses, eight PCs, and 38 GCs attempted during 2018 crossing season were raised and transplanted in the field condition for their evaluation.

Selection in seedling (C_0) population

Based on the HR brix and other growth parameters, a total of 177 clones were selected from the seedling populations. These selected clones will be planted as C_1 clones along with standard varieties for their further evaluation.

Evaluation of advanced clonal generations

About 21 promising sugarcane clones selected in C_2 generation and promoted to the C_3 generation are under evaluation for yield and quality parameters and resistance to red rot disease. A total of 56 clones are under evaluation in C_2 generation for their growth and quality parameters. Similarly, 995 C_1 clones are also under evaluation. Observations on germination %, tiller and shoot counts, NMCs and early stage quality parameters were recorded.

Station Trial (2019-20): Ten elite sugarcane genotypes *i.e.,* LG 11991, LG 12201, LG 13001, LG 13002, LG 13009, LG 14452, LG 14494, LG 15169, LG 15267 and LG 16070 along with six standard varieties *i.e.,* Co 0238, Co 05009, CoJ 64, CoS 767, CoPant 97222 and Co 05011 are under evaluation in the Station Trial (2019-20) for their growth, yield and quality parameters. Observations on germination %, tiller and shoot counts, NMCs and early stage quality parameters were recorded.

Development of sugarcane clones/varieties for North Central Zone

Hybridization and seedling raising: A total of 23 bi-parental crosses and 16 GCs were attempted at NHG, ICAR-SBI, Coimbatore during November, 2018. In addition, fluff of eight poly- crosses were also received for evaluation. The fluff was sown in the net house to raise seedling population and planted during September, 2019.

Multiplication of promising clones: Five promising entries were selected on the basis of Station Trial observations (2018-19) for inclusion in AICRP (S) trial (NCZ) and all entries are being maintained/multiplied for further actions. Eight entries along with checks specified for the North Central Zone were planted for Station Trial 2019-20. Among the eight entries, five recorded MR reaction against red rot.

Evaluation of early sugarcane clones for North West Zone

Initial Varietal Trial (Early): A trial comprising of nine sugarcane genotypes, *viz.*, Co 15025, Co 16029, CoLk 16201, CoLk 16202, CoPb 16211, CoPb 16181, CoPant 16221, CoPant 16222 and CoS 16231 along with three standards (CoJ 64, Co 0238, Co 05009) is being conducted. Observations on germination per cent, tiller and shoot counts, NMCs and early stage quality parameters were recorded.

Advanced Varietal Trial I-Plant (Early): Six sugarcane genotypes, *viz.*, Co 15023, Co 15024, Co 15027, CoLk 15201, CoLk 15205 and CoPb 15212 along with three standards (CoJ 64, Co 0238, Co 05009) are being evaluated for yield and quality parameters. Observations on germination per cent, tiller and shoot counts, NMCs and early stage quality parameters were recorded.

Advanced Varietal Trial II-Plant (Early): Four sugarcane clones, *viz.*, Co 14034, CoLk 14201, CoPb 14181 and CoPb 14211 along with three standards (CoJ 64, Co 0238, Co

05009) are being evaluated for yield and quality parameters. Observations on germination per cent, tiller and shoot counts, NMCs and early stage quality parameters were recorded.

Advanced Varietal Trial-Ratoon (Early): Four sugarcane clones, *viz.*, Co 14034, CoLk 14201, CoPb 14181 and CoPb 14211 along with three standards (CoJ 64, Co 0238, Co 05009) are being evaluated for yield and quality parameters in ratoon crop. Observations on tiller and shoot counts, NMCs and early stage quality parameters were recorded.

Seed Multiplication (Early): The seed of eight sugarcane genotypes, *viz.*, CoLk 17201, CoLk 17202, CoLk 17203, CoPb 17211, CoPb 17212, CoPant 17221, CoS 17231 and CoS 17232 is being multiplied for next year's IVT trial.

Evaluation of mid-late sugarcane clones for North West Zone

Initial Varietal Trial (Mid-late): Seven sugarcane clones, *viz.*, Co 16030, CoLk 16203, CoLk 16204, CoPb 16212, CoPant 16223, CoS 16232, and CoS 16233 along with three standards (CoS 767, CoPant 97222, Co 05011) are being evaluated for yield and quality parameters. Observations on germination %, tiller and shoot counts and NMCs were recorded.

Advanced Varietal Trial I-Plant (Mid-late): Seven sugarcane genotypes, *viz.*, Co 15026, CoLk 15206, CoLk 15207, CoLk 15209, CoPb 15213, CoS 15232 and CoS 15233 along with three standards (CoS 767, CoPant 97222, Co 05011) are being evaluated for yield and quality parameters. Observations on germination per cent, tiller and shoot counts and NMCs were recorded.

Advanced Varietal Trial II-Plant (Mid-late): Seven genotypes, *viz.*, Co 14035, CoH 14261, CoLk 14203, CoLk 14204, CoPb 14184, CoPb 14185 and CoS 14233 along with three standard varieties (CoS 767, CoPant 97222 and Co 05011) are being evaluated for yield and quality parameters. Observations on germination per cent, tiller and shoot counts and NMCs were recorded.

Advanced Varietal Trial-Ratoon (Mid-late): Seven genotypes, *viz.*, Co 14035, CoH 14261, CoLk 14203, CoLk 14204, CoPb 14184, CoPb 14185 and CoS 14233 along with three standard varieties (CoS 767, CoPant 97222, Co 05011) are being evaluated for yield and quality parameters in ratoon crop. Observations on tiller and shoot counts and NMCs were recorded.

Seed multiplication (Mid-late): The seed of 15 sugarcane varieties, *viz.*, Co 17018, CoH 17261, CoH 17262, CoLk 17204, CoLk 17205, CoPb 17213, CoPb 17214, CoPb 17215, CoPant 17223, CoPant 17224, CoS 17233, CoS 17234, CoS 17235, CoS 17236 and CoS 17237 is being multiplied for next year's IVT trial.

Defining ideotypes in sugarcane for moisture deficit condition

A total of 28 progenies of bi-parental, self and general crosses of *Saccharum* hybrid including five check varieties were planted for assessment of yield and juice quality in RBD with three replications under irrigated and drought conditions during 2019-20. All the recommended cultural practices were adopted to raise good and healthy crop. Drought was imposed at tillering phase up to onset of first seasonal rainfall. To monitor and quantify the water stress, soil moisture content was recorded at regular intervals. During stress period, relative water content, chlorophyll a, b and carotenoids were estimated. Observations recorded in previous year experiments were tabulated and analyzed. The analyzed data of two experiments (plant and ratoon crop) in different water regimes suggested that among 96 genotypes, eight genotypes namely, CoP 09437, CoP 15441, CoP 14436, BM 1010168, LG 011707, LG 08758, LG 11706, LG 10726 maintained their superiority for yield against the check varieties CoLk 94184, Co 0233 and BO 91 during both the years, while, CoP 14436, LG 011707 and LG 08758 had better ratooning under both the conditions. Among the tested entries, CoLk 94184 maintained its superiority under both the conditions and years for juice analysis.

Mapping of loci linked to sugar content in sugarcane

The project aims to identify molecular markers linked to sugar content and to map the loci linked to the trait, making use of segregating populations and high sugar in sugarcane genotypes. This year, the promising high sugar genotypes in different clonal generations selected during 2018-19 are being evaluated for their morphological and quality attributes. An advanced trial of 30 genotypes with mean sucrose per cent in juice values 19% or more in January is being evaluated. The other experiments include evaluation of approximately 90 genotypes in the third clonal stage and about 150 genotypes in the second clonal stage. Segregating populations for molecular marker studies were also maintained in the field for laboratory studies. The maintenance of the experiments was done as per the standard practices. A satisfactory crop stand was obtained in almost all the genotypes being evaluated.

Hand Refractometer brix readings were recorded during October-November and the promising clones were earmarked. The morphological studies and juice analyses have been initiated from November 2019 and are continuing. Approximately 15-20 clones were identified with high sucrose content (17-18% sucrose in juice) in November, from the various trials. Out of these, five clones are the progenies from LG 07408 GC, a high

sugar genetic stock. Three promising clones LG 11991, LG 14452 and LG 14494 are being evaluated in the divisional station trial for probable inclusion in AICRP (Sugarcane) multi-location trials.

Three high sugar genetic stocks, *viz*., LG 14482, LG 14564 and LG 11440 with sucrose % juice values 19-20% during January, were sent to National Hybridization Garden, ICAR-SBI, Coimbatore during the year for probable use as parental clones in hybridization programme. Approximately 15 matings were proposed and attempted (till the first week of November 2019) involving the high sugar genetic stocks LG 09487, LG 09475, LG 08422, LG 07482 and other clones, at NHG, ICAR-SBI, Coimbatore. A promising early maturing clone CoLk 19201 (LG 12429) was accepted in 2019 for multilocation testing in the AICRP (Sugarcane) trials. Thirty promising genotypes in different clonal stages were subjected to testing for red rot reaction during 2018-19 and the evaluation is being carried out.

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

This project was initiated to unravel the profile of conserved and novel miRNA in response to red rot disease as this disease caused by fungus *Colletotrichum falcatum* is one of the most important diseases of sugarcane in India and not much is known about its genetic control. Besides, microRNAs play a critical role in plant's adaptation towards many biotic and abiotic stresses, so it would be a critical step to identify them from red rot challenged sugarcane in order to understand the small RNA-guided gene regulation. So far, high-quality reads from small RNA libraries of sugarcane varieties BO 91 and CoJ 64 (red rot resistant and susceptible, respectively) inoculated with *C. falcatum* (Cf 08) predicted more than 300 known miRNA (in each sample) and 472 novel miRNA based on hairpin structure of the small RNA precursor having 12,566 target genes associated mostly with cellular and metabolic processes, cell or organellar development and some with disease resistance mechanism. Further to this, up to ninety-one differentially expressed miRNA were also identified. Most of the differentially expressed miRNA were equally expressed in both the varieties under red rot challenged conditions. Expression trend of known miRNA was almost similar in both the genotypes. These differentially expressed miRNA will be validated further. Taken together, our findings serve as evidence for the association of miRNA levels and their expression, with molecular mechanism underlying pathogenesis of red rot.

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

Micropropagation technique of plant tissue culture assumes significance for rapid multiplication of new varieties with superior traits and production of disease-free genetically uniform seed cane. This year, *in vitro* cultures of new sugarcane varieties CoLk 12207 and CoLk 12209 were established, and multiplied through enhanced axillary shoot proliferation using apical shoot explants. Shoot initiation was achieved on Murashige and Skoog's medium supplemented with 4.44 µM benzyladenine (BA) and 4.6 µM kinetin (Kin) + 3% sucrose. The maximum shoot proliferation per explant with 100% shoot regeneration frequency was obtained on MS medium supplemented with 2.22 µM BA + 2.3 µM Kin + 26.8 µM NAA + 3% sucrose. Vigorous rooting was obtained on MS medium containing 26.8 µM NAA and 5% sucrose. The *in vitro* multiplied sugarcane varieties CoLk 09204, CoLk 11203 and CoLk 11206 from previous year were acclimatized and hardened in glass house. Such multiplied plantlets will be transferred to field in spring season.

Development of *in vitro* conservation protocol using slow-growth tissue culture techniques in sugarcane

A protocol for *in vitro* conservation of sugarcane genotype *Khakai* using slow-growth culture technique has been developed, that involved establishment of shoot-tip cultures, followed by their multiplication on MS medium with 2.22 µM BA, 0.5 µM Kinetin, 0.5µM GA_3. The slow-growth culture regime included maintenance of cultures at 25^{0}C on MS medium supplemented with 2.22 µM BA, 0.5 µM Kinetin, 0.5µM GA_3, 5% sucrose and 5.0 µM flurprimidol (a chemical growth retardant). The cultures could be stored for up to 365 days without any sub-culture. After slow-growth period, the green parts of the cultures could be regenerated on MS medium with 2.22 µM BA, 0.5 µM Kinetin, 0.5 µM GA_3 and 3% sucrose. Successful shoot multiplication without any genetic variation in the recovered cultures was recorded from such stored slow-growing shoots incubated for 360 days.

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

An Accredited Test Laboratory (ATL) for genetic fidelity and virus indexing of tissue culture raised plants is under operation at IISR, Lucknow with the financial support from Department of Biotechnology (DBT), New Delhi under National Certification System of Tissue Culture-raised Plants (NCS-TCP). The aim of this ATL is to enhance the production and distribution of tissue

culture-raised genetically uniform and virus free planting materials to the farmers. During April to December 2019, a total of 7,176 samples were tested, out of which 2,512 samples comprising of 530 samples of sugarcane and 1,982 samples of banana from DBT recognized tissue culture production facilities were tested for mother stock virus indexing. Of the 7,176 samples, a total of 4,664 samples (490 of sugarcane and 4,174 samples of banana) were tested for genetic fidelity testing, which equals to quality certification of ~40 lakh tissue culture plantlets, for which test reports, certificate of quality as well as quality labels were issued. The testing includes virus indexing of sugarcane for Sugarcane mosaic virus (SCMV), Sugarcane yellow leaf virus (SCYLV), 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).

RNAseq-based bulk segregant analysis for SNP mining and linkage mapping for early sucrose accumulation in sugarcane

Genotyping by Sequencing (GBS) and RNAseq were used to identify QTLs and condition-specific SNPs for sucrose accumulation in sugarcane. For GBS, DNA from 131 F_1 individuals and their two parental genotypes (CoV 92102 and MS 68/47) was digested with *Ape*K1 and the GBS library was prepared from the digested DNA by ligating specific adaptors to the cut-site. The library pools were sequenced on Illumina HiSeq 2000 platform to generate an average of 0.9 GB data per sample. The monoploid sugarcane genome sequence published by Garsmeur *et al.* (Nature Comm. 2018 :9(1):2638) was used as a reference for mapping the raw reads. The allelic dosage data was estimated using the SUPERMASSA software. Only non-duplicated and single dose loci were used for linkage mapping using ONEMAP R-package. Markers that showed a LOD score of >5.5 and a recombination fraction of <0.40 were considered to be linked based on Kosambi mapping function. In this way, a total of 5,677 non-redundant single dose SNP markers were obtained from which 560 were mapped into 142 linkage groups. Following this, composite-interval-mapping (CIM) method was adopted in QTL Cartographer software package for identification of 10 QTLs (Table 1.3) for agronomically important traits including sucrose (Fig. 1.3). Further refinement and consolidation of the linkage map is being carried out.

In another approach, BSRseq was employed to identify differentially expressed genes (DEGs) and non-synonymous genetic variants (NSVs) associated with sucrose accumulation using high and low sugar parents and their two F_1 bulks (for extremes for sucrose accumulation). RNAseq libraries of two extreme bulks and the parents identified 9905 condition- specific NSVs, of which 43 had a very high degree of differential enrichment for sucrose accumulation condition (Fig. 1.4). Significant positive and negative effect NSVs were identified that were located in the coding regions of genes

Table 1.3. List of identified QTLs along with their additive effect estimates and annotation

QTL	Additive effect	Linkage group	ID	Ref	Alt	Annotation	Gene
Cane_Density1	-0.84	1	S2_1098903	T	G	intergenic region	
NMC_1	-0.96	2	S162_782	C	T	downstream gene variant	Sh_240J16_t000020
NMC_2	0.92	48	S10_32676935	A	C	downstream gene variant	Sh10_t017740
Sucrose_2	0.41	76	S9_20669112	T	C	upstream gene variant	Sh09_t010250
Sucrose_3	-0.49	131	S5_1029565	G	A	intergenic region	
Sucrose_4	-0.53	2	S4_20642247	C	G	missense variant	Sh04_t011540
Corr_Brix_1	0.31	4	S4_42469710	C	A	intergenic region	
Early_Sucrose_2	0.6	19	S110_20602	C	T	intergenic region	
Early_Sucrose_3	0.33	65	S1_755106	G	A	downstream gene variant	Sh01_t000560
Cane_width_1	-0.84	88	S2_40688711	C	G	3_prime_UTR_variant	Sh02_t023310

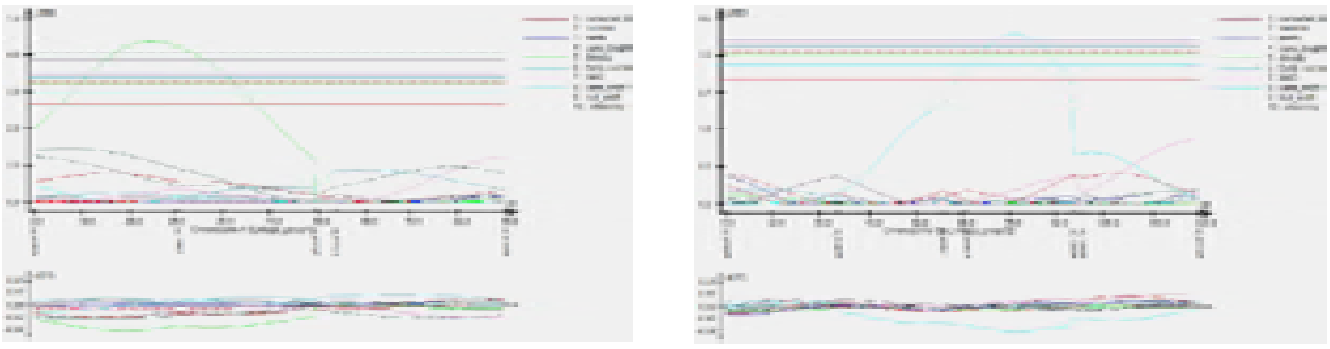


Fig. 1.3. Identification of QTLs and flanking markers for cane density and cane width using composite interval mapping

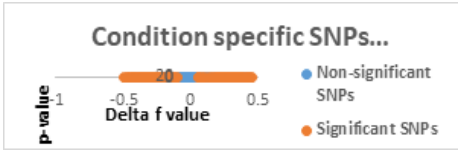


Fig. 1.4. Identification of condition-specific SNPs that are positively and negatively correlated to sucrose accumulation

involved in sucrose metabolism, photosynthesis, mitochondrial electron transport, glycolysis and transcription. In addition, a few differential pre-mature stop codons that could result in production of truncated proteins were also detected in genes coding for aquaporin, GAPDH, aldolase, cytochrome C-oxidase, chlorophyll synthase and plant plasma membrane intrinsic proteins. Additionally, a total of 2140 differentially expressed genes (DEGs) linked to high sucrose accumulation were identified. Among the DEGs, sucrose phosphate synthase III, genes involved in transport, auxin signal transduction, *etc.*, were upregulated, while those involved in electron transfer, cytochrome P450, *etc.*, were downregulated in high sucrose accumulation conditions. This study was able to give finer insights in to the role of allelic heterozygosity on sucrose accumulation and the identified NSVs and DEGs could be useful as candidate markers in marker-assisted breeding for developing high sugar varieties.

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

This year, a total of 153 reference varieties of sugarcane were maintained in DUS field during autumn and spring seasons. This reference collection includes all the identified, released and notified varieties from CVRC, varieties released from states and clones from Advanced Varietal Trials of AICRP(S) available with different research organizations working on sugarcane. DUS characters were recorded on 125 varieties in reference collection as per the DUS testing guidelines.

Seed production in agricultural crops (ICAR Seed Project)

During year 2019-20, approximately 8,200 quintals of seed cane would be produced (Table 1.4). The lifting of seed cane is ongoing and is estimated that approximately 75% seed cane of improved varieties of sugarcane has been lifted. The rest has been utilized for further multiplication and distribution to farmers. In addition, 5.0 ha area was planted with newly released varieties for seed cane production during Autumn planting of 2019. New varieties CoLk 12207 and CoLk 12209 were included for seed production from the current year. Under Seed Cane Awareness, seed of newly released varieties CoLk 11206, CoLk 09204, CoLk 9709 and others was distributed to farmers and several sugar

Table 1.4. Expected sugarcane seed production at ICAR-IISR, Lucknow during 2019-20

Variety	Group	Approximate quantity of available seed (q)
CoPk 05191	Early	900
CoLk 94184	Early	800
CoLk 9709	Early	700
CoLk 09204	Mid-late	2,500
CoLk 11206	Mid-late	800
CoLk 11203	Early	200
Co 0238	Early	900
Co 0118	Early	400
Co 05011	Mid-late	300
CoLk 14201	Early	700
Total		**8,200**

industries for making the sugarcane growers aware about the role of new varieties and the quality seed cane in enhancing the yield and production. Approximately, 100 quintal Breeder Seed Cane of different varieties was distributed to 15-20 farmers under Kumbhi Sugar Mill through an Institute project aimed at promoting newly released varieties. 'Field Days' to popularize recently notified varieties *viz*. CoLk 09204, CoLk 11206, CoLk 11203, CoLk 12207 and CoLk 12209 would be organized at the Institute. Awareness for morphological identification of varieties with DUS characters under field condition was also taken-up with development staff and farmers.

Bihar Sugarcane Breeder Seed Production Programme

Breeder seed production programme at IISR RC, Motipur (Bihar) was started during 2013-14 and first phase of this project was successfully completed during 2018-19. After successfully addressing all the objectives of the project, a Memorandum of Understanding (MOU) has been signed for a second time between ICAR-Indian Institute of Sugarcane Research, Lucknow and Sugarcane Industries Department, Government of Bihar, on December 19, 2019 for quality seed cane production in Bihar with an outlay of ₹ 120 million for next five years (2019-2024).

Breeder seed of mega varieties is being produced in area >65.0 hectares at five different sugar mills of Bihar since 2015 to 2019 and IISR Regional Centre, Motipur generated nearly ₹ 80.0 *Lakh* every year as revenue after selling breeder seed to different agencies of Bihar. During 2018-19, breeder seed production has been performed in 67.2 ha area of IISR RC, Motipur, Harinagar Sugar Mills (Harinagar), Vishnu Sugar Mill (Gopalganj), Jayshree Sugar Mill (Majholia), Tirupathi Sugars Ltd. (Bagaha) and New Swadeshi Sugar Mill (Narkatiaganj). This year, nearly 29.5 thousand q breeder seed of varieties namely, CoLk 94184, Co 0238, Co 0118, and CoP 9301 has been produced at above said centres.

CHAPTER 2

Natural Resource Management

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

An experiment was planted during second week of November 2018 (2019-20 crop season) to enhance the crop productivity and profitability of autumn sugarcane planted in wide row spacing through high value intercrops at ICAR-IISR, Kharika Research Farm. The experiment comprising twelve treatment combinations was laid out in RBD with three replications under three wide row spacings (90, 120, 150 cm.) and three intercrops (maize, garlic and fenugreek). The sugarcane variety used was Co 0238. The intercropped varieties were VMH 150 for maize, G 323 for garlic and USK 120 for fenugreek. The experiment was laid out with the objectives to find out the appropriate wide row spacing of sugarcane suitable for intercropping and to enhance system productivity & profitability and to assess the effect of various intercrops on soil quality parameters in sugarcane based system and to identify compatible high value crops for intercropping in sugarcane.

Effect of sugarcane on yield of intercrops

The intercrops were taken in between two rows of sugarcane planted under three wide row spacings (90, 120, 150 cm). Among different intercrops, autumn sugarcane at 120 cm row spacing + garlic (1:5 ratio) produced maximum yield (140.48 q/ha) and fetched the highest total income of ₹ 7,72,622/ha (Fig. 2.1). The next best treatment was observed with sugarcane at 150 cm

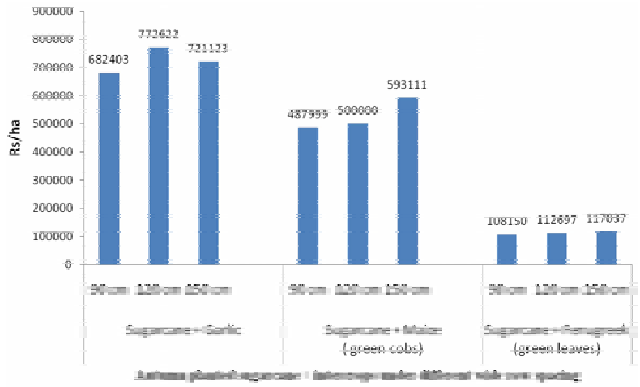


Fig. 2.1. Total income (₹/ha) of high value intercrops planted with autumn sugarcane (2019-20)

row spacing + maize green cobs (1:3 ratio) with 1.97 lakh green cobs/ha and total income ₹ 5,93,111/ha. The other intercrop fenugreek produced maximum green leaves (117.04 q/ha) under sugarcane at 150 cm row spacing + fenugreek (1:4 ratio) and total income of ₹ 1,17,037/ha was highly remunerative. The initial results were encouraging and indicated that autumn sugarcane based intercropping holds great promise in doubling the net income of farmers as compared to the sole sugarcane.

Sugarcane growth indicators

Wide row spacing treatments remarkably influenced the growth parameters at different stages as it altered the crop geometry. The sugarcane germination percentage was in the range of 35.92% to 45.83% (Table 2.1). Numerically higher tillers and shoot population of

Table 2.1. Growth of autumn sugarcane planted in wide row spacing plus intercrops

Treatment		Germination (%)	Tiller/shoot count (000/ha)		Plant height (cm)	
			90 DAP	120 DAP	120 DAP	180 DAP
T1	Sugarcane sole at 90 cm spacing	45.39	125.18	112.04	**190.6**	**270.1**
T2	Sugarcane sole at 120 cm spacing	40.32	**144.28**	**140.28**	179.3	262.1
T3	Sugarcane sole at 150 cm spacing	39.07	135.93	131.85	177.1	263.0
T4	Sugarcane at 90 cm spacing + Garlic (1:3)	42.22	117.13	112.22	190.0	257.5
T5	Sugarcane at 120 cm spacing + Garlic (1:5)	37.38	135.71	135.32	**197.4**	**277.5**
T6	Sugarcane at 150 cm spacing + Garlic (1:7)	40.00	**149.63**	**137.41**	194.9	274.3
T7	Sugarcane at 90 cm spacing + Fenugreek (1:2)	38.38	122.50	117.22	184.3	**262.5**
T8	Sugarcane at 120 cm spacing + Fenugreek (1:3)	38.33	**133.17**	**136.51**	**198.2**	258.8
T9	Sugarcane at 150 cm spacing + Fenugreek (1:4)	38.05	129.63	123.70	176.4	260.8
T10	Sugarcane at 90 cm spacing + Maize (green cobs -1:1)	45.83	85.46	107.41	**169.3**	232.1
T11	Sugarcane at 120 cm spacing + Maize (green cobs -1:2)	41.42	**88.25**	**113.09**	147.1	**238.0**
T12	Sugarcane at 150 cm spacing + Maize (green cobs -1:3)	35.92	79.63	87.22	144.1	232.1
	SEm ±	3.28	8.14	13.23	8.3	9.7
	CD (P=0.05)	NS	24.03	NS	24.6	28.5
	C.V.	14.15	11.69	18.91	11.8	13.6

sugarcane was recorded under the treatment of sugarcane at 150 cm row spacing + garlic intercropping (149.63 thousand /ha at 90 DAP and shoot count (137.41 thousand/ha at 120 DAP) as compared to sugarcane sole (90 cm row spacing) in the conventional planting (125.18 thousand /ha at 90 DAP and 112.04 thousand/ ha at 120 DAP, respectively). The highest plant height of sugarcane was recorded at 120 cm row spacing + fenugreek intercropping (198.2 cm at 120 DAP) and sugarcane at 120 cm row spacing + garlic intercropping (277.5 cm at 180 DAP). The lowest shoot population was observed under sugarcane intercropped with maize (for green cobs) as the competition for nutrients, space as well as sunlight was created which affected the growth of sugarcane.

The experiment is under progress and in-depth data on vital indicators are being generated.

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

A field experiment was initiated *w.e.f.* June 2019 with the objective to identify the best cropping system with respect to income generation. The experiment consists of ten treatments [(Rice/*Tulsi/Kalmegh*–Wheat/ *Isabgol*/ *Stevia*/ *Ashwagandha*/ wild marigold/autumn sugarcane–Spring sugarcane (plant)–Sugarcane (ratoon)–*Mentha)*] with three replications (Table 2.2). The *Kharif* season crops in the sequence have been harvested during November 2019 and the succeeding crops were planted as per treatments. The experiment is under progress.

Developing sugarcane based integrated farming system models for small farm holders of sub-tropical India

Integrated farming system is one of the important principles for achieving the goal of higher yields of different component crops and enterprises, livelihood security, soil health management, nutritional security, by-product recycling, eco-friendly agri-system, employment generation throughout the year by adopting principles of sustainable agriculture. Keeping these points in view, an experiment on sugarcane based integrated farming system was planned and executed with the objective to develop integrated farming system models for small farm holders.

In spring planted sugarcane: Intercropping of sugarcane + onion, sugarcane + maize (net income ₹ 3,20,761/ha), sugarcane + ladies finger, sugarcane + green gram was observed. The results clearly indicate that spring intercropping systems also hold promise in increasing the net income as compared to sole sugarcane. The above systems also recorded higher B: C Ratio (3.20).

The farming system *i.e.* Sugarcane (0.8 ha)-+Vegetable (0.2)+Backyard poultry+Fisheries system has been employed and data is being recorded in this system with sugarcane alone throughout the year.

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

Conservation agriculture (CA) in sugarcane based production system

A field experiment to assess the effect of conservation agriculture practices on i) the productivity and profitability of sugarcane based production system and ii) soil quality parameters in 'rice-wheat-sugarcane-ratoon-wheat system' was initiated during June 2017 with sowing of rice as direct seeded rice (DSR) mode followed by sowing of wheat crop during November 2017, again followed by planting of sugarcane after harvest of wheat in March 2018, and then followed by sugarcane ratoon (initiated in March 2019). The experiment was comprised of 24 treatments in split-split plot design with three replications. The four treatments *viz.* conventional tillage without crop residue; conventional tillage with crop residue incorporation;

Table 2.2: Treatment plan consisting of medicinal and aromatic plants in sugarcane based cropping system

Treatment	2019-20 (June)		2020-21			2021-22 (May)			2022-23
	Kharif	*Rabi*	*Zaid*	*Kharif*	*Rabi*	*Zaid*	*Kharif*	*Rabi*	*Zaid*
T1	Rice	Wheat	Sugarcane (spring)			Sugarcane Ratoon			Wheat
T2	Marigold	*Isabgol*	Sugarcane (spring)			Sugarcane (Ratoon)			Mint
T3	*Tulsi*	Wild marigold	Sugarcane (spring)			Sugarcane (Ratoon)			Mint
T4	*Tulsi*	*Ishabgol*	Sugarcane (spring)			Sugarcane (Ratoon)			Mint
T5	*Tulsi*	*Ashwagandha*	Sugarcane (spring)			Sugarcane (Ratoon)			Mint
T6	*Tulsi*	Sugarcane (Autumn) + Wild marigold)				Sugarcane (Ratoon)			Mint
T7	*Kalmegh*	*Ishabgol*	Sugarcane (spring)			Sugarcane (Ratoon)			Mint
T8	*Kalmegh*	Wild marigold	Sugarcane (spring)			Sugarcane (Ratoon)			Mint
T9	*Kalmegh*	Sugarcane (Autumn) + Wild marigold				Sugarcane (Ratoon)			Mint
T10	*Tulsi*	*Stevia*	Sugarcane (spring)			Sugarcane (Ratoon)			Mint

zero tillage without crop residue; zero tillage with crop residue retention in main plot; two treatments *viz.* with and without brown manuring in sub-plot and three treatments *viz.* recommended doses of nitrogen (RDN) ; 75% of RDN and125% of RDN in sub-sub plot.

Data presented in Table 2.3 revealed that brown manuring in rice and different nitrogen doses led to significant improvement in the production of effective tillers and 1000-grain weight in rice and wheat. Rice grain yield was recorded 11.13 per cent higher with brown manuring compared to that without brown manuring. Less weed population was recorded in zero tillage in comparison to that under conventional tillage. Conventional tillage enhanced wheat grain yield to the tune of 10.48 per cent compared to that without crop residue incorporation of previous crop and 18 per cent higher grain yield was recorded with zero tillage with crop residue over conventional tillage, and 7.7 per cent higher over conventional tillage with crop residue. Brown manuring recorded 7.6% higher wheat yield over without brown manuring. Data embodied in Table 2.4 revealed that tillage practices also influenced the tiller production in sugarcane. The increase in tiller production was recorded less than 1% higher with conventional tillage (2.14 lakh/ha) over zero tillage (2.12 lakh/ha) with crop residue management. Crop residue management (retention/incorporation of crop residue of rice and wheat) treatment recorded increase in tiller production in sugarcane to the tune of 9.44% over without crop residue management. Influence of the application of different doses of nitrogen and brown manuring in system was statistically similar in the production of tillers at 45 and 120 DAI. Sugarcane crop is standing in the field and is under observation during the reference period.

Table 2.4. Effect of tillage and management practices on tiller production in sugarcane

Treatment	Shoot count at 45 DAI (Lakh/ha)	Tiller no. (Lakh/ha)	
		120 DAI	180 DAI
Conventional tillage with residue retention	1.227	3.332	2.138
Conventional tillage without residue retention	1.194	2.937	1.946
Zero tillage with residue retention	1.251	3.298	2.117
Zero tillage without residue retention	1.194	2.879	1.941
CD (P=0.05)	NS	NS	0.129
With brown manuring	1.217	3.154	2.048
Without brown manuring	1.216	3.069	2.023
CD (P=0.05)	NS	NS	NS
Recommended dose of nitrogen (RDN)	1.133	3.081	1.982
75% of RDN	1.243	3.160	2.060
125% of RDN	1.273	3.123	2.065
CD (P=0.05)	NS	NS	NS

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

A field experiment conducted during 2018 -2019 to assess the effect of split application of NPK under drip fertigation on sugarcane plant crop as well as ratoon cane productivity. The experiment comprising seven treatments was laid out in RBD with four replications. The soil of the experimental field was low in O.C. and medium in NPK. Paired planting (120:30 cm) of sugarcane variety CoLk 11206 was done in trenches on 8 Feb, 2018. Plant cane harvesting was done in the first week of February 2019 and was left for ratoon initiation.

Table 2.3. Effect of tillage and management practices on yield and yield attributes of rice and wheat

Treatment	Rice*			Wheat		
	Effective tillers/sm	1000 grain wt. in g	Yield q/ha	Effective tillers/sm	1000 grain wt. in g	Yield q/ha
Conventional tillage with crop residue	213	22.37	30.24	230.11	34.54	41.11
Conventional tillage	213	22.37	30.24	222.28	33.77	37.53
Zero tillage with crop residue	201	22.18	29.83	237.83	34.70	44.28
Zero tillage	201	22.18	29.83	228.06	34.24	39.76
CD at 5%	NS	NS	NS	4.13	0.17	0.64
Brown manuring	214	22.80	31.57	233.78	35.21	42.28
Without brown manuring	200	21.75	28.49	225.36	33.55	39.30
CD at 5%	12.78	0.234	0.243	2.92	0.12	0.45
75% of RDN	197	22.12	28.12	217.42	34.00	38.88
100% of RDN	206	22.32	30.44	233..38	34.46	41.69
125% of RDN	219	22.40	31.54	237.92	34.69	41.81
CD at 5%	15.28	NS	0.608	3.57	0.15	0.56

*No residue of previous crop

There was significant variation among different treatments on growth parameters of 1st ratoon sugarcane crop (Table 2.5). Shoot count measured at 60 DAP was recorded higher under application of 100% RDF of NPK (T4) and under 10% additional to 100% RDF of NPK (T7) application over rest of the treatments. But there was no significant difference between T4 and T7 in number of shoot recorded at 60 and 120 days after initiation (DAI) of ratoon. The lower shoot count at 60 DAI was recorded in farmers' practice. All the drip fertigated treatments were significantly superior over farmers' practice except the treatment No. T6 in which 50% RDF of NPK was delivered through drip. Similarly, tillers count at 120, 180 and 210 DAI of ratoon, the T4 and T7 treatments showed their superiority over rest of the treatments. The superior growth parameters under drip fertigation were mainly attributed to the splitting of N fertilizer as the N applied through drip gave maximum increase in the growth parameters over the farmers' practice. Further combining N fertilizer splitting with either P or K through drip increase the yield but at lower magnitude. The number of tillers increased under different treatments at 120 DAI was to the extent of 7.6 to 17 .8% over the shoot count made at 60 DAI .

Table 2.5. Effect of different treatments on plant growth

Treatment No.	Treatment	Shoot count (000/ ha) at 60 DAP	Tillers count (000/ha)		
			At 120 DAP	At 180 DAP	At 210 DAP
T1	Conventional	121.00	130.25	110.00	91.65
T2	N through drip + PK basal	161.00	183.25	139.00	119.05
T3	NP drip + K basal	166.00	187.75	149.038	128.08
T4	100% NPK drip	178.00	208.00	162.623	142.5
T5	75% NPK drip	154.00	170.00	127.688	106.08
T6	50% NPK drip	124.00	136.00	95.45	80.43
T7	100% NPK through drip*	187.5	221.25	179.5	157.89
	C.D. at 5%	11.26	13.89	9.71	12.36

* 10% additional NPK was applied.

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

Ratoon crop is economical due to reduction in operation cost. Sugarcane ratoon management is one of the best options to reduce the cost of production and improving the farmer income as around 50% area of sugarcane is under ratoon crop. Fertilizer management practice is one of the factors that influence sugarcane production and quality in plant as well as ratoon crop. The current experiment focuses on management aspect target based nutrient application, management of late planted ratoon crop, weed management and its effect on yield. In this experiment, main crop was planted with four dates of planting with a single variety *i.e.,* CoLk 09204 during the months of February, March, April and May. The germination percentage was 32.35, 30.5, 27.4 and 25 per cent in February, March, April and May planted treatments, respectively. February planted cane recorded higher germination percentage than the later planting dates. The number of tillers counted at 180 days after planting (DAP) were 123.1, 123.8, 115.5 and 85 thousand/ha in February, March, April and May planted treatments, respectively. The crop has been initiated from February to May, 2020 and is under observation.

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

A field experiment was conducted during 2019-20 to assess the effectiveness of various microbial cultures in increasing the ratoon cane productivity and the effect of microbial cultures on soil quality parameters in multi-ratooning system. The experiment comprising of fourteen treatments in combination with three nutrients management levels and four levels of microbial consortia along with two controls was laid out in RBD with three replications. The experiment was laid with plant crop using sugarcane variety cv. CoLk 09204 planted on March 1, 2019. The difference in number of tillers recorded at different stages of crop growth were non significant. Microbial culture of different nutrients have been isolated, characterized and identified. The microbial cultures have also been tested for compatibility. All the microbial cultures have been identified as having no negative response. These microbial cultures are *Gluconacetobacter sacchari* for N, *Pseudomonas fluoresens* for P, *Enterobacter cloacae* for K, *Acinetobacter calcoaceticus* for Zn and *Pseudomonas nitroreducens* for S. The experiment was taken up to generate information on the efficacy of these microbial cultures on the succeeding ratoon crop.

Sugarcane productivity in relation to initial soil organic carbon content and nutrient management in sub-tropical *Inceptisol*

A field experiment was initiated in March 2015 to assess the influence of initial soil organic carbon (SOC) content and nutrient management on sugarcane growth and yield in a multi-ratooning system. During the period under report (2019), analyses of post-harvest soil samples was done and soil health as influenced under various treatments was assessed. The experimental field consisted of plots (8 x 6 m) with varying initial SOC content as a result of additions at variable rates of different bio-manures continuously for 10 years in a

plant ratoon system followed by a fallow year. Four initial SOC levels (0.45-0.55, 0.56-0.65, 0.66-0.75 and above 0.75%) and three nutrient management packages (recommended dose of fertilizers (RDF): 150, 60, 60 kg NPK; RDF + farmyard manure 10 t/ha; RDF + zinc sulphate 25 kg/ha + S 20 kg/ha) were evaluated in all combinations (12) following randomized block design with three replications. Farmyard manure was added in the stipulated plots at the time of ratoon initiation and mixed well. Whereas total quantity of zinc sulphate and sulphur were applied in the furrows as per the treatment. Soil and plant samples were drawn at different intervals to record soil physical, physico-chemical, microbial properties and plant biometric parameters.

Soil organic carbon recorded at various stages of the plant – ratoon I- ratoon II – ratoon III cropping system revealed maintenance of the trend of soil organic carbon status in sugarcane soils under the system. With higher initial SOC status, soil continued to contain higher SOC till the end over those plots having lower initial SOC. However, SOC declined with time and with each successive ratoon except under the treatment where farmyard manure (10 t/ha) was continuously applied along with RDF. The finding underlines the importance of continuous organic manure addition in sugarcane fields for the sake of soil health maintenance in sugarcane production systems. It is also noteworthy that sugarcane cultivation *per se* helped in maintaining SOC level even under lower initial SOC and application of RDF alone in sub-tropics.

Table 2.6. Effect of initial soil organic carbon content (SOC) and nutrient management on soil organic carbon (%) at different stages of the plant – ratoon I – ratoon II – ratoon III system

Treatment	At plant crop harvest	At ratoon II harvest	At system end
Initial SOC level			
0.45-0.55	0.65	0.63	0.52
0.56-0.65	0.76	0.54	0.55
0.66-0.75	0.82	0.61	0.61
≥ 0.76	0.74	0.71	0.69
Nutrient management			
RDF (150, 60, 60 kg NPK/ha)	0.76	0.57	0.52
RDF + FYM (10 t/ha)	0.77	0.74	0.75
RDF + $ZnSO_4$ 25 kg + S 20 kg/ha	0.70	0.60	0.58

Soil quality assessment under different sugarcane growing systems

About 122 soil samples were collected from the Khatauli sugar mill command areas of Muzaffarnagar district of Uttar Pradesh to assess the nutrient status and soil quality. The pH of the soil samples ranged from 6.90 to 8.50 with average value of 8.07, indicating the existence of a variety of soils that are neutral to alkaline in nature but electrical conductivity found in normal range which varied from 0.05 to 0.22 dS/m with average of 0.10 dS/m. The organic carbon content in sugarcane growing areas varied from very low (0.23%) to high range (0.89%) with average values of 0.51%. The nutrient index (NI) of soil organic carbon was 1.58 which comes under low categories (NI <1.67 is considered low, 1.67-2.33 medium and >2.33 high). The available N, P and K varied from 134.8 to 244.5, 3.51 to 29.9 and 60.3 to 405.5 kg/ha with average values of 184.4, 18.2 and 146.1 kg/ha, respectively. All the soil samples collected from the Khatauli sugar mill command areas were deficient in respect of available N as it exhibited nutrient index value at 1.0. The nutrient index of available P (2.10) and K (1.76) was in medium range. The sulphur content varied from 5.88 to 22.8 kg/ha with average value of 12.0 and 23.4% coefficient of variations. The nutrient index showed medium categories of sulphur content. The Zn, Cu, Fe and Mn content varied from 0.08 to 1.92, 0.28 to 2.54, 4.06 to 45.7 and 2.92 to 19.6 mg/kg with mean values of 0.72, 0.84, 12.4 and 8.10 mg/kg, respectively (Table 2.7). The nutrient index of Zn was under medium categories whereas nutrient index of Cu, Fe and Mn was under higher categories as NI was observed at >2.33.

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

A research project on developing scientific aids for site specific nutrient management through variable mapping of soil properties in sugarcane growing soils

Table 2.7. Descriptive statistics of soil samples from Khatauli sugar mill command area, Muzaffarnagar District, Uttar Pradesh

Parameter	pH (1:2.5)	EC (dS/m)	OC (%)	Available nutrient (kg/ha)				Micronutrient (mg/kg)			
				N	P	K	S	Zn	Cu	Fe	Mn
Minimum	6.90	0.05	0.23	134.8	3.51	60.3	5.88	0.08	0.28	4.06	2.92
Maximum	8.50	0.22	0.89	244.5	29.9	405.5	22.8	1.92	2.54	45.7	19.6
Average	8.07	0.10	0.51	184.4	18.2	146.1	12.0	0.72	0.84	12.4	8.10
SD	0.25	0.04	0.16	23.6	4.64	52.3	2.81	0.44	0.35	8.25	2.76
CV (%)	3.08	37.2	30.7	12.8	25.5	35.8	23.4	61.1	41.4	66.4	34.1
Nutrient index	-	-	1.58	1.00	2.10	1.76	1.72	1.70	2.94	2.63	2.97

have been initiated during the year 2019. The objectives of project were i) to characterize the variability in soil properties, relationship among them and identify most contributing parameters in soil quality, ii) to find out the best fit geo-statistical semivarigram models of soil properties and develop spatial distribution maps and iii) to identify potential soil management zones based on the soil properties status and spatial delineation of identified management zones. To begin with, the study has been initiated in Central Uttar Pradesh at ICAR-IISR research farm at Lucknow.

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

Looking at the importance of silicon as a multi-functional element in highly Si accumulator sugarcane crop, the experiment was initiated with the aim to assess the plant available silicon status in sugarcane growing soils and to find out the suitable source and optimum dose of silicon for enhancing sugarcane productivity. The project has been started with the collection of soil samples to determine the plant available silicon. The analysis of soil samples is under finalization.

Management of bioresources for enhancing sugarcane productivity and soil health

The application of chitosan in agriculture has recently become major focus of growth improvement, fungicides and seed coating agents. Chitosan has a direct effect on treated plants and induces a series of defense reactions in treated plants. Further Chitosan and its derivatives exhibit excellent antibacterial, antiviral, antifungal, abiotic stress tolerance like drought tolerance, salt tolerance properties. An experiment was undertaken in Spring 2019 to work out the efficacy of oligochitosan (biostimulator) and other bioresources and their integration in sugarcane productivity and soil health. With the 12 different treatment combinations *viz.*, T_1: 100% N:P:K (Control),T_2 : 75% N:P:K (Control), T_3 : T_1 + Use of Biostimulator derivative @ 2.5 ml/l of water*, T_4: T_3 + sett treatment (*Gluconacetobacter diazotrophicus*), T_5: T_4 + sett treatment (*Bacillus subtilis*), T_6: T_5 + sett treatment (*Bacillus cerelus*), T_7: T_6 + foliar application of GA_3 @ 35 ppm at 90, 120 and 150 DAP, T_8: T_2 + Use of Biostimulator derivative @ 2.5 ml/l of water*, T_9: T_8 + sett treatment (*Gluconacetobacter diazotrophicus*), T_{10}: T_9 + sett treatment (*Bacillus subtilis*), T_{11}: T_{10} + sett treatment (*Bacillus cerelus*), T_{12}: T_{11} + foliar application of GA_3 @ 35 ppm at 90, 120 and 150 DAP. The design of experiment was RBD with three replications. The experiment is under observation and initial results will be available by next year.

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

A serious issue in sugarcane cropping is the presence of weeds in cultivated areas and their management which require significant expenditure.. *Ipomoea* spp. emerge late and develop during the growth phase of sugarcane and compete with the crop and may cause yield reduction up to 20-25%. Their control is important and is a concern on the sugarcane growth and yield. To control these binding weed, we must understand biology and growth behaviour of these plants. The objective of this study was to record growth behaviour of this weed under its different density. A pot experiment entitled "Effect of density of *Ipomoea* spp. on its growth behaviour" was conducted to devise an integrated weed management programme for sugarcane production. Observations on plant height, root length, plant dry matter accumulation, root dry weight, leaf number per plant and leaf area per plant were taken at 30, 60, 90, 120 and 150 days after sowing.

Modulating application of sugarcane production technologies for harnessing production and productivity potential in farmers' field perspective

Under this project, farm trials were laid for summer as well as autumn planted sugarcane, based on the preferential choices of the stakeholders *i.e.* practicing sugarcane growers, sugarcane researchers, sugar mill authorities and sugarcane development personnel. During summer (April 2019), on-farm trials of two newly released varieties namely, CoLk 09204 (early group) and CoLk 11206 (mid-late group) were selected for varietal performance at farmers' fields in Kumbhi Chini Mill, Kumbhi, Lakhimpur reserved zone. On-farm trials were initiated on April 30, 2019 with recommended dose of fertilizers application on the basis of soil health test. The soil analysis revealed pH (7.7), EC (0.133), OC (0.56%) as normal, nitrogen (188.2 - 304.3 kg/ ha.) as low to medium while phosphorous (64.4 - 78.5 kg/ha.) and potash level (289 – 294 kg/ha) were high. Both the varieties, CoLk 09204 and CoLk 11206 were found in good vigour and crop stand. The sugarcane growers and sugar mill personals liked both varieties owing to expected good cane yield and no infestation of diseases and pests.

During autumn 2019, six on-farm trials of sugarcane varieties namely, CoLk 11206, CoLk 14201 and CoLk 09204 with intercrop mustard were laid out at the farmers' fields in Patna and Majhia villages under Kumbhi Chini Mill, Kumbhi, Lakhimpur reserved zone. The cane seed (67.53 q) covering 1.16 ha was provided to the growers. The experiment was laid on November 25, 2019 as autumn planted sugarcane.

CHAPTER 3

Management of Insect-Pests and Diseases

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

Insect-pests survey was conducted in Command areas of Loni Sugar Mill, Biswan Sugar Mill, Sitapur, and Chilbaria Sugar Mill, Bahraich. The incidence of internode, top and stalk borer (5-6%) was noticed at several locations in Loni sugar mill area. At one location, cane leaves damaged by unidentified weevil were observed. The incidence of a black beetle (*Heteronychus* sp.) was observed at several locations that contributed more than 30% of dead heart in Biswan and Chilberia Sugar Mill areas. Sporadic incidences of pink borer and stalk borer were also observed. In one field, incidence of termite and white grub was also noticed. Incidence of a black Delphacid Plant Hopper, *Eoeurysa flavocapitata* was reported again from Muzaffarnagar district in Western Uttar Pradesh. A severe incidence of *Pyrilla perpusilla* was observed in Narsinghpur district of Madhya Pradesh. Besides the pest, a good number of its parasitoid, *Epiricania melanoleuca* was also seen in the area. An attack of army worm *Mythimna separata* was observed in maize in Hasanpur area of Bihar.

Sugarcane diseases surveys were conducted for occurrence of different sugarcane diseases on commercial varieties in different cane growing area of Uttar Pradesh and Bihar during 2019-20 crop season. In Uttar Pradesh, the sugar mill area surveyed were Command areas of DSCL Sugar Mill, Hariawan, Hardoi; Bajaj Hindusthan Group; Simbhaoli Sugar Mills, Chilwariya; Balrampur Chini Mill Group; Dalmia Chini Mill Group; Hargaon Oudh Sugar Mill; Seksaria Biswan Chini Mill, Biswan; Gularia Chini Mill, Nausar, Gularia, Lakhimpur; Tulsipur Sugar Company Limited, Gonda; Saraya Sugar Mills Ltd., Gorakhpur; Kushinagar and DSCL Sugar, Loni, Shahabad, Hardoi.

- Red rot was recorded in CoJ 85, Co 0238, CoSe 95422, CoS 8436, Co 87263, CoLk 8102, CoS 95255, CoSe 01424 and CoS 91269. Incidence of red rot in Co 0238 was 7% to 60%. About 30% incidence of the disease was recorded in CoSe 95422 and CoS 8436.
- Smut incidence (5 to 15 per cent) was recorded in Co 0238, CoSe 92423, CoS 88230 and CoS 91269.
- Yellow Leaf Disease (YLD) incidence was 10 to 40% in Co 0238.
- Incidence of GSD was noticed in most of the field surveyed to the tune of 3 to 15% while at some locations, the incidence (15-35%) was higher in CoS 91269, CoLk 94184 and CoJ 85.
- The incidence of Pokkah boeng (30%) was recorded only in Co 0238.
- Eye spot caused by *Helminthosporium sacchari*, brown spot caused by *Cercospora longipes* and ring spot caused by *Leptosphaeria sacchari* were also recorded in most of the area to the tune of 3 to 10%.

In Bihar, Harinagar Sugar Mills Limited, Harinagar, West Champaran; Champaran Sugar Company Ltd, Barachakiya, East Chmparan; HPCL Sugar and Biofuel, Ltd, Lauriya, West Champaran; Vishnu Sugar Mills, Gopalganj; New Swadeshi Sugar Mills, Narkatiaganj, West Champaran; Majhauliya Sugar Mills, West Champaran; HPCL Biofuels Ltd., Suaguli, Bihar and Hasanpur Sugar Mills, Hasanpur, Samastipur command areas were monitored.

- Varieties *viz.*,CoLk 94184, Co 0118, Co 0238, CoSe 01421, Co 0232, CoSe 96234, CoSe 95422, CoSe 92423, Co 89029, BO 128 and Co 87263 were observed in sugarcane cultivation during 2019-20 in Bihar.
- The incidence of red rot was recorded in the varieties namely CoSe 92423, CoSe 95422, Co 0238, BO 128 and CoSe 96234 to the tune of 5-35%.
- Yellow Leaf Disease (YLD) was noticed in the varieties *viz.*, Co 0238, Bo 128, CoP 06436, CoLk 94184 and Co 0118.
- Higher incidence of YLD (15 to 35%) was recorded at some locations of East and West Champaran on Co 0238 and BO 128.
- Eye spot caused by *Helminthosporium sacchari*, brown spot caused by *Cercospora longipes* and ring spot caused by *Leptosphaeria sacchari* were also recorded in most of the area to the tune of 2 to 15%
- Pokkah Boeng was observed in the varieties *viz.*, CoP 06436, BO 154, CoP 9301, Co 0238, CoSe 95422, Co 0118, CoLk 94184, Co 0239, BO 130 and CoP 112. The incidence of Pokkah Boeng was increased in the variety Co 0238 (15-30%).
- The incidence of GSD was increasing and observed to be 5 to 10 per cent in all the areas.

Plant Pathology

Management of Yellow Leaf Disease (YLD) of sugarcane through thermotherapy

Yellow Leaf Disease of sugarcane is sett borne caused by phytoplasma/virus. Diseased cane setts may play pivotal role in spreading and perpetuation of disease. Planting of healthy seed (without pathogen) may be one of the best options for the management of disease. To inactivate the pathogen, thermotherapy based experiments were conducted.

Yellow Leaf Disease (YLD) infected canes of sugarcane *cv.* CoLk 94184 were treated with five different heat treatment regimes in MHAT. T_1 = 2h for first day +2h for second day +2h for third day; T_2 = 2h for first day +1h for second day +1h for third day; T_3 = 2h for first day +2h for second day +1h for third day; T_4 = 1h for first day +1h for second day +1h for third day at 50°C and T_5 = Normal MHAT (54°C for 2.5 h) along with two controls *viz.*, T_6 Healthy seed cane; T_7 Diseased seed cane.

In none of the treatments and controls, infection was seen up to 199 days after planting. Infection was observed 200 DAP in 5 plants in T_4 and 8 plants in T_7. Infection of disease was observed in 6, 5, 10 and 15 plants in T_2, T_3, T_4 and T_7, respectively 250 DAP. In T_1 (Serial thermotherapy for two hours for three consecutive days, germination was 42.47% while it was 37.62% in T_5 (standard MHAT).

Enhancing efficacy of *Trichoderma* based red rot management system

Application of three promising *Trichoderma* isolates (STr-64, STr-83 and STr-126) enhanced germination from 17.5 to 29.2% over control.

For the evaluation of effect of three promising *Trichoderma* isolates *viz.*, STr-64, STr-83 and STr-126 on growth promotion in sugarcane, field experiment was laid out in randomized block design with Co 0238 during March 2019 and 13 treatments: T_1 to T_3: application of the selected *Trichoderma* isolates as sett treatment (sett dipping in *Trichoderma* spore suspension @ 10^6 spore/ml) and soil application through *Trichoderma* colonized FYM (@ 200 kg/ ha) at time of planting; T_4 to T_6: application of *Trichoderma* isolates as sett treatment and soil application through FYM + 50% RDF (recommended dose of fertilizers 150:60:60); T_7 to T_9: application of selected *Trichoderma* isolates as sett treatment and soil application through FYM + 100% RDF; T_{10}: FYM +100% RDF; T_{11}: FYM +50% RDF; T_{12}: FYM alone and T_{13}: control (No FYM or inorganic fertilizers). The results revealed that the germination ranged between 29% (control) and 37.5% (STr-64 + 100% RDF) in the different treatments. It was also observed that application of the three *Trichoderma* isolates alone or in combination with different fertilizer doses resulted in an increase of 17.5 to 29.2% in germination over control. These treatments also showed increase in germination by 7.0 to 17.6% over sole FYM application (T_{12}).

Evaluation/screening of sugarcane germplasm/genotypes against red rot and smut

During 2019, seventy seven germplasm/genotypes *viz.*, LG 14530, LG 14538, LG 14438, LG 14418, LG 14488, LG 14493, LG 14531, LG 14505, LG 14455, LG 14552, LG 14478, LG 14468, AC-12, AC-13, AC-14, AC-15, AC-16, AC-17, AC-18, AC-19, AC-20, LG 14519, LG 14445, LG 14433, LG 14510, LG 14440, LG 13447, LG 14504, LG 14408, LG 14498, LG 14544, LG 12481, LG 14521, LG17127, LG 17137, LG 17140, LG 17141, LG 17143, LG 17154, LG 17156, LG 17185, LG 14434, LG 14495, LG 15433, LG 13444, LG 14420, LG 14453, ST-1, ST-2, ST-3, ST-4, ST-5, ST-6, LG 17197, LG 17201, LG 17205, LG 17209, LG 17212, LG 17214, LG 17219, LG 17224, ST-7, AC-1, AC-2, AC-3, AC-4, AC-5, AC-6, AC-7, AC-8, AC-9, AC-10, AC-11, LG 17226, LG 17236, LG 17238 and LG 17288 were screened against red rot (Cf 08 and Cf 09) and smut. Natural incidences of wilt and Yellow Leaf Disease (YLD) were also recorded.

Reaction of genotypes against red rot

During 2019, seventy seven genotypes were evaluated against red rot. Out of them, nine genotypes *viz.*, AC-20, LG 15433, ST-2, ST-4, AC-7, AC-8, AC-9, AC-10 and AC-11 were resistant (R) to both pathotypes. Eight genotypes *viz.*, LG 14445, LG 14510, LG 14498, LG 14544, LG 14495, LG 17197, LG 17219, AC-3 were rated as susceptible (S) to both the pathotypes. Ten genotypes *viz.*, LG 14538, LG 14531, LG 14504, LG 14408, LG 14521, LG17127, LG 14434, LG 14453, ST-6 and LG 17238 were rated as highly susceptible (HS) to both the pathotypes. Thirty two genotypes *viz.*, LG 14530, LG 14418, LG 14505, AC-12, AC-13, AC-15, AC-16, AC-17, AC-18, AC-19, LG 14440, LG 17137, LG 17140, LG 17141, LG 17154, LG 17156, LG 13444, LG 14420, ST-1, ST-3, ST-5, LG 17201, LG 17209, LG 17212, LG 17214, LG 17224, ST-7, AC-1, AC-4, AC-5, AC-6 and LG 17226 were moderately resistant (MR) against both pathotypes. Eleven genotypes *viz.*, LG 14493, LG 14455, LG 14552, LG 14468, AC-14, LG 13447, LG 17143, LG 17185, LG 17205, LG 17236 and LG 17288 were moderately susceptible (MS) against both pathotypes. Genotype AC-2 was rated as resistant (R) against Cf 08 and moderately resistant (MR) against Cf 09. Three genotypes *viz.*, LG 14438, LG 14478 and LG 12481 were found moderately resistant (MR) against Cf 08 and moderately susceptible (MS) against Cf 09. Two genotypes *viz.*, LG 14519 and

LG 14433 were found moderately susceptible (MS) against Cf 08 and susceptible (S) to Cf 09. Genotype LG 14488 was rated as susceptible (S) against Cf 08 and highly susceptible (HS) against Cf 09.

Reaction of genotypes against Smut

Fifty nine genotypes *viz*., LG 14538, LG 14438, LG 14488, LG 14493, LG 14505, LG 14455, LG 14552, LG 14478, LG 14468, AC-12, AC-13, AC-14, AC-15, AC-16, AC-17, AC-18, AC-19, AC-20, LG 14519, LG 14445, LG 14433, LG 14510, LG 14440, LG 13447, LG 14504, LG 14498, LG 14544, LG 12481, LG17127, LG 17137, LG 17141, LG 17154, LG 17156, LG 14434, LG 14495, LG 15433, LG 13444, LG 14420, LG 14453, ST-1, ST-2, ST-3, ST-4, ST-5, ST-6, LG 17197, LG 17219, ST-7, AC-1, AC-2, AC-3, AC-4, AC-5, AC-6, AC-7, AC-8, AC-9 AC-10 and AC-11 were rated as resistant (R). Seven genotypes *viz*., LG 14521, LG 17143, LG 17185, LG 17201, LG 17205, LG 17209 and LG 17236 were moderately resistant (MR). Seven genotypes *viz*., LG 14530, LG 14418, LG 14531, LG 14408, LG 17140, LG 17224 and LG 17288 were moderately susceptible (MS). Four genotypes *viz*., LG 17212, LG 17214, LG 17226 and LG 17238 were susceptible (S) and no highly susceptible (HS) reaction was observed in any of the genotypes.

Wilt

Twenty genotypes *viz*., LG 14530, LG 14468, AC-12, AC-13, AC-14, AC-15, AC-16, AC-17, AC-18, AC-19, LG 14445, LG 14433, LG 14440, LG 17141, LG 17154, LG 17156, LG 17185, LG 14420, LG 17197 and LG 17288 were rated as susceptible (S) and remaining 57 genotypes *viz*., LG 14538, LG 14438, LG 14418, LG 14488, LG 14493, LG 14531, LG 14505, LG 14455, LG 14552, LG 14478, AC-20, LG 14519, LG 14510, LG 13447, LG 14504, LG 14408, LG 14498, LG 14544, LG 12481, LG 14521, LG17127, LG 17137, LG 17140, LG 17143, LG 14434, LG 14495, LG 15433, LG 13444, LG 14453, ST-1, ST-2, ST-3, ST-4, ST-5, ST-6, LG 17201, LG 17205, LG 17209, LG 17212, LG 17214, LG 17219, LG 17224, ST-7, AC-1, AC-2, AC-3, AC-4, AC-5, AC-6, AC-7, AC-8, AC-9, AC-10, AC-11, LG 17226, LG 17236 and LG 17238 were resistant (R).

YLD

Eleven genotypes *viz*., LG 14438, LG 14418, LG 14493, LG 17137, LG 17185, LG 14495, LG 13444, ST-5, ST-7, AC-10 and LG 17288 were rated as susceptible (S) and remaining 66 genotypes *viz*., LG 14530, LG 14538, LG 14488, LG 14531, LG 14505, LG 14455, LG 14552, LG 14478, LG 14468, AC-12, AC-13, AC-14, AC-15, AC-16, AC-17, AC-18, AC-19, AC-20, LG 14519, LG 14445, LG 14433, LG 14510, LG 14440, LG 13447, LG 14504, LG 14408, LG 14498, LG 14544, LG 12481, LG 14521, LG17127, LG 17140, LG 17141, LG 17143, LG 17154, LG 17156, LG 14434, LG 15433, LG 14420, LG 14453, ST-1, ST-2, ST-3, ST-4, ST-6, LG 17197, LG 17201, LG 17205, LG 17209, LG 17212, LG 17214, LG 17219, LG 17224, AC-1, AC-2, AC-3, AC-4, AC-5, AC-6, AC-7, AC-8, AC-9, AC-11, LG 17226, LG 17236 and LG 17238 were rated as resistant (R).

Identification of pathotypes of red rot pathogen

During 2019-20, thirteen new isolates *i.e.,* twelve isolates from Co 0238 (IR-171, IR-172, IR-173, IR-174, IR-175, IR-176, IR-177, IR-178, IR-179, IR-180, IR-181 and IR-182) and one from CoLk 8102 (IR-183) were evaluated for their virulence on 19 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 , Khakai (*S. sinese*), SES 594 (*S. spontaneum*) and Baragua (*S. officinarum*) by plug method of inoculation and their reactions were compared with Cf 07, Cf 08 and Cf 09. Except Co 0238 isolates, the virulence pattern of other isolates more or less similar with the existing pathotypes of this zone as reported in earlier result (2018-19). It was observed that Co 0238 isolates giving intermediate reaction to BO 91, Co 7717, CoJ 64, Co 419, CoSe 95422 and Baragua; susceptible reaction to Co 975, Co 62399, CoC 671, Co 86002, CoV 92102 and Khakai and resistant reaction to CoS 8436, CoS 767, Co 997, Co 1148, Co 86032 and SES 594, thus, indicating the existence of gained virulence for BO 91, Co 975, Co 62399, Co 86002 and CoV 92102 and loss of virulence for CoS 767, Co 997, CoS 8436, Co 1148 and Co 86032.

The virulence pattern of Co 0238 isolates did not match with the red rot isolate of CoLk 8102 and also with designated pathotypes (Cf 07, Cf 08 and Cf 09) of sub-tropical zone, thus, clearly indicating the existence of gained specific virulence of Co 0238 isolates on its host which is different from the existing pathotypes of this zone.

Apart from the above work, red rot designated pathotypes of sub-tropical zone have also been deposited in different repositories, details of which are as follows:

A. National Agriculturally Important Microbial Culture Collection:

1. Accession Number: NAIMCC –F-03382 for *Colletotrichum falcatum* pathotype Cf 07
2. Accession Number: NAIMCC –F-03383 for *Colletotrichum falcatum* pathotype Cf 09
3. Accession Number: NAIMCC –F-03384 for *Colletotrichum falcatum* pathotype Cf 08

B. NCBI Accession Details:

1. Accession Number: MG786760- *Colletotrichum falcatum* pathotype Cf 07
2. Accession Number: MG786761- *Colletotrichum falcatum* pathotype Cf 08
3. Accession Number: MG786762- *Colletotrichum falcatum* pathotype Cf 09

Evaluation of zonal varieties against red rot, smut and wilt

North West Zone (IISR, Lucknow)

Forty genotypes including nine of Initial Varietal Trial (Early) *viz.*, Co 15025, Co 16029, CoLk 16201, CoLk 16202, CoPb 16211, CoPb 16181, CoPant 16221, CoPant 16222 and CoS 16231; six of Advanced Varietal Trial (Early)-I Plant *viz.*,Co 15023, Co 15024, Co 15027, CoLk 15201, CoLk 15205 and CoPb 15212; four of Advanced Varietal Trial (Early)-II Plant *viz.*, Co 14034, CoLk 14201, CoPb 14181 and CoPb 14211; seven of Initial Varietal Trial (Mid late) *viz.*, Co 16030, CoLK 16203, CoLk 16204, CoPb 16212, CoPant 16223, CoS 16232 and CoS 16233; seven of Advanced Varietal Trial (Mid late)-I Plant *viz.*, Co 15026, CoLk 15206, CoLk 15207, CoLk 15209, CoPb 15213, CoS 15232 and CoS 15233; seven of Advanced Varietal Trial (Mid late)-II Plant *viz.*, Co 14035, CoH 14261, CoLk 14203, CoLk 14204, CoPb 14184, CoPb 14185 and CoS 14233 were screened against red rot, smut (artificial infection) and natural infection of wilt and yellow leaf disease along with susceptible checks *viz.*, CoJ 64 (Cf 07 and Cf 08) and CoS 767(Cf 09) for red rot and CoLk 7701 and Co 1158 for smut.

Red rot

In IVT (Early), out of nine genotypes, one genotype CoLk 16201 was resistant (R) by both the methods of inoculation (plug and nodal) against both the pathotypes (Cf 08 and Cf 09). Seven genotypes *viz.*, Co 15025, Co 16029, CoLk 16202, CoPb 16181, CoPant 16221, CoPant 16222 and CoS 16231 were rated as moderately resistant (MR) by plug method and resistant (R) by nodal method of inoculation against both the pathotypes. One genotype CoPb 16211 was rated as highly susceptible (HS) by plug method and susceptible (S) by nodal method against both the pathotypes.

In AVT (Early)–I Plant, out of six genotypes, five genotypes *viz.*, Co 15023, Co 15027, CoLk 15201, CoLk 15205 and CoPb 15212 were rated as moderately resistant (MR) by plug method and resistant (R) by nodal method against both the pathotypes. Co 15024 was rated moderately susceptible (MS) by plug method and susceptible (S) by nodal method against both the red rot pathotypes.

In AVT (Early)-II Plant, out of four genotypes, three genotypes *viz.*, CoLk 14201, CoPb 14181 and CoPb 14211 were rated as moderately resistant (MR) by plug method and resistant (R) by nodal method against both the red rot pathotypes. Co 14034 was rated moderately susceptible (MS) by plug method and resistant (R) by nodal method against both the red rot pathotypes.

In IVT (Mid late), out of seven genotypes, five genotypes *viz.*, CoLk 16203, CoLk 16204, CoPant 16223, CoS 16232 and CoS 16233 were moderately resistant (MR) by plug method and resistant (R) by nodal method against both the red rot pathotypes. Co 16030 was rated as moderately susceptible (MS) against Cf 08 and susceptible (S) against Cf 09 by plug method, whereas rated as susceptible (S) by nodal method against both the red rot pathotypes. CoPb 16212 was susceptible (S) by both the methods of inoculation against both the red rot pathotypes.

In AVT (Mid late)-I Plant, out of seven genotypes, CoLk 15206 was resistant (R) by both the methods of inoculation against both the red rot pathotypes and six genotypes *viz.*, Co 15026, CoLk 15207, CoLk 15209, CoPb 15213, CoS 15232 and CoS 15233 were rated moderately resistant (MR) by plug method and resistant (R) by nodal method against both the red rot pathotypes.

In AVT (Mid late)-II Plant, out of seven genotypes, six genotypes *viz.*, Co 14035, CoH 14261, CoLk 14203, CoLk 14204, CoPb 14184 and CoPb 14185 were rated moderately resistant (MR) by plug method and resistant (R) by nodal method against both the red rot pathotypes. CoS 14233 was moderately susceptible (MS) by plug method where as resistant (R) by nodal method against both the pathotypes.

Smut

Three bud setts were dipped in teliospore suspension (10^6 spores/ml) for 30 minutes and planted. Smut incidence was recorded at fortnightly intervals up to the harvest of the crop.

Out of 40 genotypes, 20 genotypes *viz.*, Co 16025, Co 16029, CoPant 16221, CoPant 16222, Co 15023, Co 15024, CoLk 15201, CoLk 15205, Co 14034, CoLk 14201, CoPb 14211 Co 16030, CoLk 16203, CoS 16233, CoLk 15206, CoLk 15207, CoPb 15213, CoS 15233, Co 14035 and CoLk 14203, were resistant (R). Ten genotypes *viz.*, CoLk 16202, CoS 16231, CoPb 14181, CoLk 16204, CoPant 16223, CoS 16232, Co 15026, CoH 14261, CoPb 14184 and CoPb 14185 were moderately resistant (MR). Four genotypes *viz.*, CoPb 16181, Co 15027, CoPb 16212 and CoS 15232 were moderately susceptible (MS). Four genotypes *viz.*, CoLk 16201, CoPb 16211, CoLk 14204 and CoS 14233 were rated as susceptible (S) and two genotypes CoPb 15212 and CoLk 15209 were highly susceptible (HS).

Wilt

Out of 40 genotypes screened under natural inoculums' pressure, five genotypes *viz.*, CoPb 16211, Co 15024, CoPb 14211, CoPb 16212 and Co 15026 were rated as highly susceptible (HS). Fourteen genotypes *viz.*, Co 16025, Co 16029, CoPant 16222, Co 15023, Co 15027, Co 14034, Co 16030, CoPant 16223, CoPb 15213, CoS 15233, CoPb 14185 and CoS 14233, Co 14035 and CoH 14261 were rated as susceptible (S). Remaining 23 genotypes were resistant (R) against the wilt.

Yellow leaf disease (YLD)

Out of 40 genotypes tested under natural infection condition, ten genotypes *viz.*, Co 16029, CoLk 16201, CoPb 16211, CoS 16231, Co 15027, CoLk 14201, CoPant 16223, CoPb 15213, CoLk 14203 and CoPb 15212 were rated as susceptible (S) against YLD. Remaining 30 genotypes were found resistant (R) to YLD.

North Central Zone (ICAR-IISR RC, Motipur)

In North Central Zone, 38 genotypes were screened against red rot at ICAR-IISR RC, Motipur; eight genotypes in IVT (Early) *viz.*, CoP 16436, CoP 16437, CoP 16438, CoLk 16466, CoLk 16467, CoLk 16468, CoSe 16451 and CoBln 16501; five in AVT (Early)-I Plant *viz.*, CoLk 15466, CoLk 15467, CoP 15436, CoSe 15452 and CoSe 15455; four in AVT (Early)-II Plant *viz.*, CoLk 14206, CoP 14437, CoSe 14451 and CoSe 14454; nine (09) in IVT (Mid late) *viz.*, CoP 16439, CoP 16440, BO 156, CoLk 16469, CoLk 16470, CoLk 16471, CoSe 16452, CoSe 16453 and CoBln 16502; seven in AVT (Mid late)-I Plant *viz.*, CoLk 15468, CoLk 15469, CoP 15438, CoP 15439, CoP 15440, CoSe 15453 and CoSe 15454 and five in AVT (Mid late)-II Plant *viz.*, CoLk 14208, CoLk 14209, CoP 14438, CoP 14439 and CoSe 14455 along with highly susceptible checks against Cf 07 and Cf 08 by plug and nodal methods.

Red rot

In IVT (Early), out of eight genotypes, six genotypes *viz.*, CoP 16436, CoP 16437, CoLk 16466, CoLk 16467, CoLk 16468 and CoBln 16501 were moderately resistant (MR) by plug method and resistant (R) by nodal method against both the red rot pathotypes. CoP 16438 was moderately resistant (MR) against Cf 07 and moderately susceptible (MS) against Cf 08 by plug method whereas resistant (R) against Cf 07 and susceptible (S) against Cf 08 by nodal method. CoSe 16451 was moderately susceptible (MS) against both the pathotypes by plug method whereas resistant (R) against red rot Cf 07 and susceptible (S) against Cf 08 by nodal method.

In AVT (Early)-I Plant, out of five genotypes, three genotypes *viz.*, CoLk 15466, CoLk 15467 and CoSe 15455 were moderately resistant (MR) by plug method and resistant (R) by nodal method against both the red rot pathotypes. CoP 15436 and CoSe 15452 were moderately resistant (MR) against Cf 07 and moderately susceptible (MS) against Cf 08 by plug method, whereas resistant (R) against Cf 07 and susceptible (S) against Cf 08 by nodal method.

In AVT (Early)-II Plant, out of four genotypes, CoLk 14206 was resistant (R) by both the methods of inoculation against both the pathotypes. CoP 14437, CoSe 14451 and CoSe 14454 were rated as moderately resistant (MR) by plug method and resistant (R) by nodal method against both the red rot pathotypes.

In IVT (Mid late), out of nine genotypes, CoLk 16470 was resistant (R) by both the methods of inoculation against both the pathotypes and seven genotypes *viz.*, CoP 16439, CoP 16440, BO 156, CoLk 16469, CoLk 16471, CoSe 16452 and CoBln 16502 were rated as moderately resistant (MR) by plug method and resistant (R) by nodal method against both the red rot pathotypes. CoSe 16453 was rated as moderately susceptible (MS) against both the pathotypes by plug method, whereas susceptible (S) against Cf 07 and resistant (R) against Cf 08 by nodal method.

In AVT (Mid late)-I Plant, out of seven genotypes, CoP 15439 was resistant (R) by both the methods of inoculation against both the pathotypes. Five genotypes *viz.*, CoLk 15468, CoLk 15469, CoP 15438, CoP 15440 and CoSe 15454 were rated as moderately resistant (MR) by plug method and resistant (R) by nodal method against both the red rot pathotypes. CoSe 15453 was rated as moderately susceptible (MS) against both the pathotypes by plug method, whereas susceptible (S) against Cf 07 and resistant (R) against Cf 08 by nodal method.

In AVT (Mid late)-II Plant, all the five genotypes tested were rated as moderately resistant (MR) by plug method and resistant (R) by nodal method against both the red rot pathotypes.

Among the standard checks *i.e.*, CoSe 95422 was susceptible (S) against both the pathotypes by both the methods. CoJ 64 was highly susceptible (HS) against both the pathotypes by both the methods. BO 130, CoP 06436 and BO 91 were moderately resistant (MR) against both the pathotypes by plug method and resistant (R) against both the pathotypes by nodal method.

Smut

Three bud setts were dipped in teliospore suspension (10^6 spores/ml) for 30 minutes before planting. Smut incidence was recorded at fortnightly intervals up to the harvest of the crop.

Out of 38 genotypes tested, 22 genotypes *viz.*,CoP 16436, CoP 16437, CoSe 16451, CoBln 16501, CoLk 15466, CoLk 15467, CoLk 14206, CoP 14437, CoSe 14451, CoLk 16470, CoLk 16471, CoBln 16502, CoLk 15468, CoLk 15469, CoP 15438, CoP 15439, CoSe 15454, CoLk 14208, CoLk 14209, CoP 14438, CoP 14439 and CoSe 14455 were rated as resistant (R). Thirteen genotypes *viz.*, CoP 16438, CoLk 16466, CoLk 16467, CoLk 16468, CoSe 14452, CoSe 15455, CoSe 14454, CoP 16440, BO 156, CoLk 16469, CoSe 16452, CoSe 16453 and CoSe 15453 were rated as moderately resistant (MR). Three genotypes *viz.*, CoP 15440, CoP 16439 and CoP 15436 were rated as moderately susceptible (MS). Five genotypes *viz.*, CoP 16438, CoSe 15452, CoLk 16470, CoSe 16452 and CoP 15440 were rated as susceptible.

Wilt

Out of 38 genotypes tested under natural conditions, five genotypes *viz.*, CoP 16438, CoSe 15452, CoLk 16470, CoSe 16452 and CoP 15440 were rated as susceptible (S) to wilt. Remaining thirty three genotypes were resistant (R).

Yellow leaf disease (YLD)

Out of 38 genotypes, six genotypes *viz.*, CoBln 16501, CoP 16440, CoLk 16470, CoP 15438, CoSe 15453 and CoLk 14209 were rated as susceptible (S) whereas remaining 32 genotypes were resistant.

Assessment of elite and ISH genotypes for resistance to red rot

Twenty six ISH genotypes namely SA04-472, SA04-454, MA/5/22, MA/5/37, PG 9869137, BM 1009-163, BM 1022-173, BA 1003143, SA04-390, SA04-496, CYM-07986, AS04-2097, BM-1009149, AS04-1687, MA5/5, SA98-13, GU07-2276, MA5/51, GU07-3849, SA04-409, BM1010168, MA5/99, AS04-1689, GU073-774, AS04-635 and AS04-245 along with two susceptible checks *viz.*, CoJ 64 (for Cf 08) and CoS 767 (for Cf 09) were again planted and evaluated under field conditions at ICAR-IISR, Lucknow against red rot pathotypes Cf 08 and Cf 09 during 2019.

- Out of 26 ISH genotypes tested, five genotypes namely SA04-454, BA 1003143, BM1010168, SA98-13 and AS04-635 were rated as resistant (R) against both the pathotypes by plug and nodal both the methods of inoculation.
- Three genotypes BM 1009-163, MA5/51 and PG 9869137 were rated susceptible (S) to both the pathotypes by plug and nodal methods.
- Two genotypes AS04-245 and GU073-774 were rated highly susceptible (HS) against both the pathotypes by plug method and susceptible (S) by nodal method.
- The genotypes BM1022-173, AS04-1687 and CYM-07986 were rated as moderately susceptible (MS) against both the pathotypes by plug method whereas resistant (R) by nodal method.
- The other 13 genotypes *viz.*, SA04-454, SA04-472, GU07-3849, MA/5/22, MA/5/37, SA04-390, SA04-496, AS04-2097, BM-1009149, MA5/5, SA04-409, MA5/99 and AS04-1689 were rated as moderately resistant (MR) to both the pathotypes by plug method and resistant (R) by nodal method.

Entomology

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

Tetrastichus howardi (Olliff) is being mass multiplied on a range of Lepidopterous pupae in the laboratory. For the present study, pupae of top borer and silk worm were used. The top borer and silk worm pupae were kept (in plastic vials wrapped in 2-3 cotton layers) in refrigerator for studying the effect of storage period on different biological attributes of the parasitoid.

Single mated female (freshly emerged) of *T. howardi* was kept in test tube (15 cm x 2.5 cm). Honey solution (50%) was provided as streaks in test tubes for feeding of female parasitoid wasp.

Each glass tube containing individual mated female parasitoid was provided with single fresh and stored pupa (2, 4, 6 and 10 days storage) of top borer and of silk worm, fresh and stored pupae (12, 40 and 60 days storage). The individual females were allowed for 24 hrs to parasitize the pupae and tubes were secured with cotton swab. Parasitized individual pupa was shifted to fresh sterile glass tube for further development of the parasitoid at 26 ±2°C and 65±5% R.H. in BOD.

Top borer

The number of adult emergence was maximum (97.2/pupa) in fresh pupae as compared to stored pupae (2, 3, 4, 6 and 10 days) of top borer and it varied between 70.6 and 92.4 with developmental period 16 to 19.8 days. As days of storage increased, number of adults decreased. The percentage female emergence was 96.5 in fresh pupae and 81.04 to 92.57% at different storage period.

Silk worm

The maximum number of adults (456.2/pupa) was obtained in fresh pupae of silk worm with

developmental period 18.6 to 19.4 days. As days of storage increased (40 to 60 days), number of adults/pupa decreased, the percentage female emergence varied from 88.56 to 91.22.

Developing arthropods-based soil health bio-indicators for subtropical sugarcane ecosystem

Soil organic carbon influenced abundance of soil micro arthropod fauna. Higher SOC (>0.70) supported higher build-up in comparison to low SOC (<0.50). However, there was not much difference in build-up of population under organic/inorganic nutrient sources in high SOC soil. On the contrary, impact of nutrient source supported higher build-up of fauna in low SOC soil.

Community structure of soil collembola and mites of sugarcane ecosystem was assessed in relation to nutrient management and also from adjacent non-sugarcane land uses. Soil parameters (EC, pH, OC, Available N P K) were analyzed in subset of the samples as per standard procedures. Berlese-Tullgren and pitfall methods were used to extract soil arthropod fauna.

In high SOC soils, organisms were higher in number than low SOC soils. Sugarcane systems have higher arthropod fauna than nearby undisturbed habitats. Effect of nutrient inputs (inorganic & organic) was more on faunal build-up in low SOC sugarcane plots in comparison to high SOC (>0.70) plots. Soil pH and EC ranged between 7.0 and 8.0 and 0.10 and 0.28 dSm^{-1} among systems. The SOC ranged between 0.39 and 1.27 per cent. Av N, Av P & Av K was low in low organic carbon soils.

Principal component analysis was conducted to identify main operating factor/s of different land uses in terms of observed parameters. The analysis indicated that 99% variability is explained by PC 1 (75.96%) and PC 2 (23.62%). PC 1 loading was dominated by abundance (0.97 factor score) and PC 2 dominated by available potassium (0.95 factor score).

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

Studies were initiated with response of male moths towards female moths in olfactometer (four armed). Females of borers (top borer and stalk borer) were kept in arms and male moths were kept in arena. A stream of wind was passed through arms with the help of electric operated vacuum pump. Response of male moths was observed visually. In the case of top borer of sugarcane, four male moths were kept in arena and single female in each arm of olfactometer, such 10 replications were maintained. In 90 per cent cases, male moths were attracted towards females but no mating was observed.

In the case of stalk borer of sugarcane, male moths were attracted by females in all ten replications or sets while mating was observed in two sets (replications) of experiments.

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

In Advanced Varietal Trial (AVT)

In early maturing group, 13+3 sugarcane genotypes *viz*., Co 14034 (II plant), Co 15027, CoLk 14201 (II Plant), CoLk 15201, CoLk 15205, CoLk 16201, CoLk 16202, CoPant 16221, CoPant 16222, CoPb 14181, CoPb 14211 (II Plant), CoPb15212, CoPb16181 and three standards (CoJ 64, Co 0238, Co 05009) and in mid late maturing group, 19+3 genotypes *viz*., Co 14035 (II Plant), Co 16030, CoH 14261, CoLk 14203 (II Plant), CoLk 14204 (II Plant), CoLk 15206, CoLk 15207, CoLk 15209, CoLk 16203, CoLk 16204, CoPb 14184 (II Plant), CoPb 14185 (II Plant), CoPb 15213, CoPb 16212, CoPant 16223, CoS 14233 (II Plant), CoS 15232, CoS 15233, CoS 116233 and three standards (Co 5011, CoPant 97222, CoS 767) (Table 3.1) were planted on March 2-4, 2019 in plots of 3.6 m x 6 m plot size with 90 cm row to row distance and each treatment was replicated three times. Recommended agronomic practices were followed to raise a good crop. No insecticide was applied at any stage of the crop.

Table 3.1. List of genotypes evaluated for their reaction against major insect pests

S.N.	Early maturing	S.N.	Mid late maturing
II Plant		II Plant	
1.	Co 14034	1.	Co 14035
2.	CoLk 14201	2.	CoLk 14203
3.	CoPb 14211	3.	CoLk 14204
II Plant		4.	CoPb 14184
4.	Co 15027	5.	CoPb 14185
5.	CoLk 15201	6.	CoS 14233
6.	CoLk 15205	I Plant	
7.	CoLk 16201	7.	Co 16030
8.	CoLk 16202	8.	CoH 14261
9.	CoPant 16221	9.	CoLk 15206
10.	CoPant 16222	10.	CoLk 15207
11.	CoPb 14181	11.	CoLk 15209
12.	CoPb 15212	12.	CoLk 16203
13.	CoPb 16181	13.	CoLk 16204
14.	CoJ 64	14.	CoPb 15213
15.	Co 0238	15.	CoPb 16212
16.	Co 05009	16.	CoPant 16223
		17.	CoS 15232
		18.	CoS 15233
		19.	CoS 116233
		20.	Co 05011
		21.	CoPant 97222
		22.	CoS 767

Table 3.2. Incidence of insect pests in early maturing genotypes (AVT)

SN	Variety	Incidence of top borer and varietal reaction						Stalk Borer		Internode borer		Mealy bug	
		II brood		III brood		IV brood							
		Inci.	Rat.	Inci.	Rat.	Inci.	Rat.	Inci.	Rat.	Inci.	Rat.	Inci.	Rat.
1.	Co 14034	3.51	T	6.63	T	31.49	S	5.58	S	6.87	T	16.44	MT
2.	Co 15027	4.84	T	4.56	T	23.66	S	14.68	S	7.68	T	16.67	MT
3.	CoLk 14201	6.38	T	4.76	T	32.72	S	6.54	S	3.88	T	11.27	MT
4.	CoLk 15201	4.86	T	3.29	T	16.61	MT	8.17	S	9.29	T	14.42	MT
5.	CoLk 15205	3.83	T	2.57	T	15.49	MT	5.51	S	4.12	T	11.75	MT
6.	CoLk 16201	6.95	T	3.33	T	8.44	T	5.05	S	6.30	T	19.48	MT
7.	CoLk 16202	4.95	T	5.38	T	41.81	S	7.55	S	8.51	T	17.87	MT
8.	CoPant 16221	2.71	T	2.15	T	22.14	S	9.83	S	5.52	T	0.00	T
9.	CoPant 16222	4.64	T	5.62	T	30.84	S	12.09	S	10.65	T	33.10	S
10.	CoPb 14181	3.60	T	4.10	T	14.33	MT	8.52	S	4.36	T	10.94	MT
11.	CoPb 14211	5.01	T	4.93	T	27.80	S	1.97	T	9.16	T	10.02	MT
12.	CoPb 15212	4.07	T	3.78	T	20.45	S	5.97	S	8.91	T	14.69	MT
13.	CoPb 16181	7.05	T	2.67	T	20.14	S	9.66	S	4.36	T	9.57	T
14.	Co 0238	4.90	T	7.98	T	49.17	S	3.23	MT	12.41	T	21.77	S
15.	Co 05009	8.93	T	7.57	T	30.88	S	5.60	S	8.87	T	15.23	MT
16.	CoJ 64	6.77	T	5.44	T	42.87	S	7.09	S	8.80	T	53.44	S

T=Tolerant, MT=Moderately Tolerant, S=Susceptible

Scale

Top borer: <10.0 Tolerant (T), 10.1-20.0 Moderately Tolerant (MT), >20.0 Susceptible (S), mealy bug<10.0 Tolerant (T), 10.1-20.0, Moderately Tolerant (MT), >20.0 Susceptible (S).

Stalk borer: <2.0 Tolerant (T), 2.1-5.0 Moderately Tolerant (MT), >5.0 Susceptible (S).

Internode borer: <20.0 Tolerant (T), 20.1-40.0 Moderately Tolerant (MT), >40.0 Susceptible (S).

In early group, germination ranged from 27.63% in Co 14034 to 52.91% in Co 0238. Incidence of top borer (II & III Brood) was <10 per cent in genotypes evaluated. Therefore, all the genotypes were rated as tolerant ones (Table 3.2).

Incidence of top borer (IV Brood) ranged between 8.44 per cent in CoLk 16201 and 49.17 per cent in Co 0238. CoLk 15201, CoLk 15205 and CoPb 14181 were MS while CoLk 16201 was tolerant to IV brood incidence of top borer.

Incidence of stalk borer ranged between 1.97 per cent in CoPb 14211 and 14.68 per cent in Co 15027. CoPb 14211 was tolerant to stalk borer, while Co 0238 was MS and rest of the genotypes were HS to stalk borer.

Incidence of internode borer was less than 20.0 per cent in all the genotypes, thus, all the genotypes were rated as tolerant to internode borer.

Incidence of root borer was <10.0% in all the genotypes including standards, therefore, all the genotypes were rated as tolerant to root borer.

Corrected brix, sucrose per cent and purity coefficients of juice in the month of November were at par in all the genotypes.

In mid late maturing group, incidence of top borer (II Brood) was <10 per cent in all the genotypes including standards. Therefore, all the genotypes were rated as tolerant ones. Co 16030 gave moderately tolerant reaction to top borer (III Brood).

Incidence of top borer (IV Brood) ranged between 8.49 per cent in CoLk 16203 and 52.06 per cent in Co 14035. Ten genotypes *viz*., Co 14035, Co 16030, CoH 14261, CoLk 14204, CoLk 15207, CoPb 14185, CoPb 16212, CoPant 16223, CoS 14233, CoS 16233 and CoS 767 were susceptible to top borer (IV Brood), seven genotypes were moderately tolerant and rest of the genotypes were tolerant (Table 3.3).

Incidence of stalk borer ranged from 4.31 to 10.85 per cent. Three genotypes *viz*., CoLk 15209, CoLk 16203 and CoS 15232 were moderately tolerant and rest of the genotypes were susceptible to stalk borer (Table 3.3).

Incidence of internode borer was less than 20.0 per cent in all genotypes, thus, all the genotypes were rated as tolerant to moderately tolerant.

Corrected brix, sucrose per cent and purity coefficients of juice in the month of November were at par in all the genotypes.

Survey and surveillance of sugarcane insect pests

Incidence of borer pests of sugarcane has decreased in western Uttar Pradesh especially early shoot borer due to excess use of Chlorantraniliprole, a borer specific insecticide.

Table 3.3. Incidence of insect pests in mid late maturing genotypes (AVT)

SN	Variety	Incidence of top borer and varietal reaction						Stalk borer		Internode borer		Mealy bug	
		II brood		III brood		IV brood							
		Inci.	Rat.	Inci.	Rat.	Inci.	Rat.	Inci.	Rat.	Inci.	Rat.	Inci.	Rat.
1.	Co 14035	5.25	T	5.94	T	52.06	S	5.49	S	14.15	MT	33.39	S
2.	Co 16030	9.42	T	10.31	MT	28.69	S	5.20	S	12.05	MT	7.04	T
3.	CoH 14261	7.93	T	8.22	T	20.5	S	5.17	S	12.92	MT	1.02	T
4.	CoLk 14203	2.22	T	1.71	T	14.7	MT	7.23	S	10.62	MT	21.95	MT
5.	CoLk 14204	3.29	T	4.56	T	28.13	S	9.76	S	14.01	MT	16.81	MT
6.	CoLk 15206	4.67	T	4.67	T	15.39	MT	7.81	S	18.12	MT	8.05	T
7.	CoLk 15207	4.28	T	4.78	T	26.72	S	10.75	S	7.41	T	9.98	T
8.	CoLk 15209	5.49	T	5.49	T	12.47	MT	4.31	MT	10.38	MT	20.43	S
9.	CoLk 16203	5.63	T	5.01	T	8.49	T	4.63	MT	8.28	T	26.91	S
10.	CoLk 16204	2.45	T	2.97	T	8.96	T	9.73	S	11.46	MT	16.25	MT
11.	CoPb 14184	5.72	T	6.12	T	14.01	MT	7.55	S	11.00	MT	18.55	MT
12.	CoPb 14185	5.33	T	5.55	T	28.25	S	10.85	S	12.79	MT	12.99	MT
13.	CoPb 15213	8.13	T	8.51	T	14.49	MT	6.28	S	10.33	MT	1.31	T
14.	CoPb 16212	3.50	T	1.72	T	25.41	S	9.24	S	11.59	MT	1.81	T
15.	CoPant 16223	7.45	T	9.18	T	28.38	S	8.47	S	7.14	T	20.75	S
16.	CoS 14233	5.35	T	1.89	T	26.87	S	7.58	S	8.52	T	13.82	MT
17.	CoS 15232	8.39	T	9.60	T	6.99	T	5.87	MT	7.68	T	17.93	MT
18.	CoS 15233	5.67	T	5.66	T	11.07	MT	7.37	S	10.34	MT	18.67	MT
19.	CoS 16233	7.57	T	7.69	T	26.45	S	7.45	S	10.22	MT	1.35	T
20.	Co 05011	3.29	T	1.87	T	9.99	T	6.2	S	11.27	MT	41.34	S
21	CoPant 97222	7.00	T	8.35	T	16.81	MT	8.75	S	19.85	MT	12.87	MT
22	CoS 767	3.51	T	4.62	T	22.9	S	6.05	S	10.47	MT	7.03	T

T=Tolerant, MT=Moderately Tolerant, S=Susceptible

Monitoring of insect pests and bio-agents in sugarcane agro-ecosystem

Field experiment was conducted to monitor the insect pests of sugarcane with three sugarcane varieties *viz*., CoLk 94184, Co 0238 and CoLk 07201. Three bud setts of all three varieties were planted in November, 2018 and all recommended agronomic practices were followed to raise a good crop. Periodic observations on incidence of insect pests and parasitoids of pests were recorded.

Incidence of top borer II brood was nil in all the three sugarcane varieties. Incidence of III brood varied from 16.22 to 18.41 per cent and incidence in IV brood increased and ranged from 38.52 to 45.86 per cent. Incidence of stalk borer, internode borer, root borer, black bug, mealy bug and white fly was high. CoLk 07201 was recorded to escape termite damage. Low incidence of white fly and *Pyrilla perpusilla* was observed (Table 3.4).

Parasitisation of top borer by *Rhaconotus* sp. and *Isotima javensis* was observed. Larval parasitisation of stalk borer and internode borer by *Cotesia flavipes* was observed. Puparium of white fly and *Pyrilla perpusilla* were parasitized by *Encarsia* sp. and *Epiricania melanoleuca* (Table 3.5).

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

Eumicrosoma spp. (Hymenoptera : Scelionidae) is a

Table 3.4. Incidence of different insect-pests of sugarcane

S. N.	Variety	Top borer		Stalk borer	Internode borer	Root borer	Termites	Black bug	Mealy bug	White fly	*Pyrilla perpusilla*
		III Brood	IV Brood								
1.	Co 0238	18.41	45.86	15.06	15.06	36.74	27.10	5.00	32.50	5.00	2
2.	CoLk 07201	17.13	38.52	18.25	19.66	33.98	0.00	15.00	19.57	12.00	2
3.	CoLk 94184	16.22	43.73	23.43	11.71	33.05	10.87	19.66	26.00	0.00	0

Table 3.5. Parasitisation of insect-pests

S. N.	Variety	Top borer		Stalk borer	Internode borer	White fly	*P. perpusilla*
		Rhaconotus sp.	*Isotima javensis*	*Cotesia flavipes*	*Cotesia flavipes*	*Encarsia* sp.	*Epiricania melanoleuca*
1.	Co 0238	15.0	6.67	14.86	13.33	25.00	50.00
2.	CoLk 07201	21.43	9.52	25.00	50.00	13.33	50.00
3.	CoLk 94184	6.67	13.33	28.57	50.00	15.00	0.00

potential egg parasitoid of black bugs of sugarcane, *Cavelerious sweeti* Myamoto and *Dimorphopterus gibbus*. *Eumicrosoma* spp. is mass multiplied in the laboratory on the eggs of laboratory reared *Dimorphopterus gibbus*. *D. gibbus* is multiplied on natural host plant.

Rearing of black bug, *Dimorphopterus gibbus* (Fabricius) and *Cavelerius Sweeti* Myamoto

There are two major steps in rearing of black bug in the laboratory:

Muslin bag for oviposition: A muslin bag (20.0 x 8.0 cm) containing cut tops of sugarcane with 5 cm leaf portion is used as egg laying bag. In one bag, 50 pairs of adult bugs are released. Bag with insects are kept in tray for egg laying. Fresh eggs are rice shaped and creamy white in colour. At maturity, eggs become dark orange in colour.

Paper cone for nymph development: Paper cone was developed by rolling a cut cane (8-10) with leaf sheath in a sterilized A4 paper. Narrow end of the paper cone was tightened with the help of rubber bands and broad upper end is closed after releasing either the mature eggs or newly hatched nymphs by locking the cone ends. Nymphs are shifted to new cone at the interval of 4-5 days in summer and 5-6 days interval in winter and rainy seasons. Nymphs hatch in 6.0 to 10 days. Life cycle is completed in 29 to 55days (Table 3.6).

Table 3.6. Duration of different life stages of *Dimorphopterus gibbus* on natural food

Duration	Incubation period (days)	Nymphal period (days)	Total period (days)
February-March	6-8	26-27	31-35
April-May	8-9	25-28	33-38
June -July	6-8	25-27	30-35
August- September	6-7	22-26	29-33
October -November	9-10	27-29	35-38
December-January	9-10	45-47	51-55

Mass multiplication of *Eumicrosoma* sp. (Hymenoptera: Sceilionidae) an egg parasitoid of Lygaeid bugs of sugarcane

Eumicrosoma sp. is a black shiny Sceilionid wasp. Eggs of black bug *D. gibbus* were used as laboratory host.

Fresh eggs (fresh or 24 hour old) are offered to the gravid female in homoeopathic vials for parasitization. Parasitized eggs became blackish in colour from one end and in few days turned completely black to shiny black just before hatching. Parasitization ranged from 10.00 to 80.00 per cent. Single gravid female could parasitize on an average of 15.67 eggs. Development period of prasitoid varies from 7-10 days. Parasitisation and longevity of adults varies from 62.89 to 80.75 per cent and 1-3.5 days, respectively (Table 3.7).

Table 3.7. Parasitisation by *Eumicrosoma* spp. and its development

Duration	Parasitisation (%)	Development period (days)	Adult emergence (%)	Longevity of adults (days)
February	40.00	8.00	72.00	1-2
March	48.00	8.00	75.00	2-3
April	55.00	8.00	65.00	1-2
May	44.00	8.00	65.50	1-2
June	50.00	8.00	75.00	1-2
July	67.00	7.00	79.00	2-2.5
August	70.00	7.00	80.00	2-3
September	80.00	7.00	82.00	2-3.5
October	75.00	7.00	75.50	2-2.5
November	59.00	8.00	62.89	2.2.5
December	35.00	9.00	79.00	1-2
January	10.00	10.00	80.75	1-1.5

Isolation and mass multiplication of an entomopathogenic fungus, *Beauveria bassiana*

The fungus was isolated from infected larvae of stalk borer during observations. Mummified larvae of borer were inoculated after cleaning with sodium hypochlorite solution in PDA in petridish and fungus colonies were obtained. Culture was further purified and pure culture of the fungus was developed.

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

Field experiment was conducted to study cane yield losses due to insect pests with Co 0238. Two blocks of 0.1 hectare were maintained. One block was kept under management practice especially insecticide (application of chlorpyriphos 20 EC @ 1.0 kg a.i./ha at planting, soil application of carbofuran @ 1.0 kg a.i./ha against III brood of top borer, foliar spray of quinalphos 25 EC @ 250 g a.i./ha against cane borers), bio-agents such as *Trichogramma* spp. and *Cotesia flavipes* have also been released. In the other block, no insect pest management practices were applied. Average per cent incidence of top borer II brood, III brood, IV brood, stalk borer, internode borer and mealy bug was 2.31, 18.91, 30.28, 13.68, 10.69 and 28.89 per cent, respectively in unprotected block while incidence of top borer II brood was nil and of III brood, IV brood, stalk borer, internode borer and mealy bug was 3.81, 5.31, 3.22, 1.86 and 6.44 per cent, respectively in protected block. Reduction in cane weight in cane damaged by top borer III brood, IV brood, Stalk borer, internode borer and mealy bug was 12.87, 19.51, 6.09, 8.80 and 18.89 per cent, respectively.

Institute Research Projects at ICAR-IISR Biological Control Centre, Pravaranagar (Maharashtra)

Survey and surveillance of insect-pests and diseases of sugarcane in sub-tropical area (Maharashtra)

During 2019, surveys were conducted at the experimental farm of Padmashri Dr. Vitthalrao Vikhe Patil Sahkari Sakhar Karkhana Ltd. Pravaranagar, Maharashtra for the seasonal prevalence of diseases and pests in different sugarcane genotypes.

Surveys were conducted to record the incidence of brown spot on sugarcane. In Pravaranagar area, CoM 265 is the major cultivated variety, incidence of brown spot was ranged from 91.38% to 97.38% in the five surveyed fields (Fig. 3.1 a). Severe occurrence was due favourable climatic conditions during the season especially heavy rainfall and high relative humidity. Similarly, 30% incidence of brown spot was also recorded on Co 13020 and Co 13009 sugarcane genotypes. Incidence of about 25-35% of YLD was also recorded on different genotypes *viz*., CoSnk 13013, CoSnk 13101Co 16018, Co 16010, Co 11015 and Co 94008 (Fig. 3.2 b). Incidence of smut was occurred in traces on Co 13008 sugarcane genotype (Fig. 3.2 c). Traces of infestation was observed due to woolly aphid on CoM 265 (Fig. 3.2 d).

Fig. 3.1 a. Incidence of brown spot on sugarcane variety CoM 265; Fig. 3.1 b. Incidence of YLD; Fig. 3.1 c, Incidence of smut in traces on sugarcane variety Co 13008; Fig. 3.1 d. Woolly aphid on sugarcane variety CoM 265

Genetic diversity and transmission of pathogens causing Yellow Leaf Disease in sugarcane

Genomic DNA of YLD affected sugarcane genotypes *viz*., Co 419, Co 453, Co 0238, Co 0233, CoLk 94184, CoS 510, CoS 91230, CoS 02258, CoS 02264, CoSe 01421, CoH 08262, CoH 08263, CoPant 96219, CoS 245, CoS 20269, CoSe 1235, CoSe 98231, CoPb 08211, CoPb 08212 and CoS 98259 was isolated using DNeasy Plant Mini Kit and these DNA samples were subjected to nested PCR assay using phytoplasma primers. Results revealed the first round PCR showed 1.8 kb size amplicons were used as a template for the second round PCR using 3F and 3R specific primers for *16S rRNA* gene. Second round PCR yielded 1.3 kb size amplicons (Fig. 3.2 a) in CoS 510 which were gel eluted and sent for Sanger sequencing. Sequencing results of this single isolate revealed the association of *Candidatus phytoplasma* belonging to the 16SrXI subgroup. BLAST results revealed 96.76% identity with *Candidatus phytoplasma oryzae*, *Amorphophallus paeoniifolius* 'leaf yellows phytoplasma', sugarcane grassy shoot and white leaf phytoplasma. The sequence information submitted to the NCBI GenBank. Further, sequence information of large number of phytoplasma isolates would be required to ascertain the genetic diversity.

During July-August, 2019 on the bunds of sugarcane fields typical phytoplasma symptoms were recorded on *Parthenium* (*Parthenium hysterophorus*), commonly called congress grass in India (Fig. 3.2 b.). The symptomatic samples were collected and sent for phytoplasma detection at Division of Plant Pathology, SBI, Coimbatore. Genomic DNA was isolated and subjected for PCR assay using custom designed 16Sr RNA gene specific primers for 16SXI subgroup of phytoplasma. 1% agarose gel electrophoresis showed amplification of 800 bp corresponding to phytoplasma

Fig. 3.2 a. 1.3 kb size amplicons yield by Second round PCR; Fig. 3.2 b. Typical phytoplasma symptoms recorded on *Parthenium* (*Parthenium hysterophorus*). Fig. 3.2 c. Amplification of 800 bp corresponding to phytoplasma infection in *Parthenium*

infection in *Parthenium* (Fig. 3.2 c). Further, the PCR product is gel eluted and submitted for sequencing.

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

The total 59 entomopathogenic bacterial isolates, out of 24 are *Bacillus thuriengensis*, 29 are *Brevibacillus* sp and 6 are *Paenibacillus* sp were isolated from the soil samples and infected grubs respectively from the endemic area of white grub infestation of PDVVPSK Ltd sugar factory area of Ahmednagar, Maharashtra. These *Paenibacillus* sp caused milky disease in white grubs and their identity were confirmed by the sporulation pattern, catalase activity and vancomycin resistance (Fig. 3.3). All paenibacillus sp isolates are catalase negative and vancomycin resistance (150 µg/ml). The glycerol stocks of pure cultures were prepared and stored at -20°C.

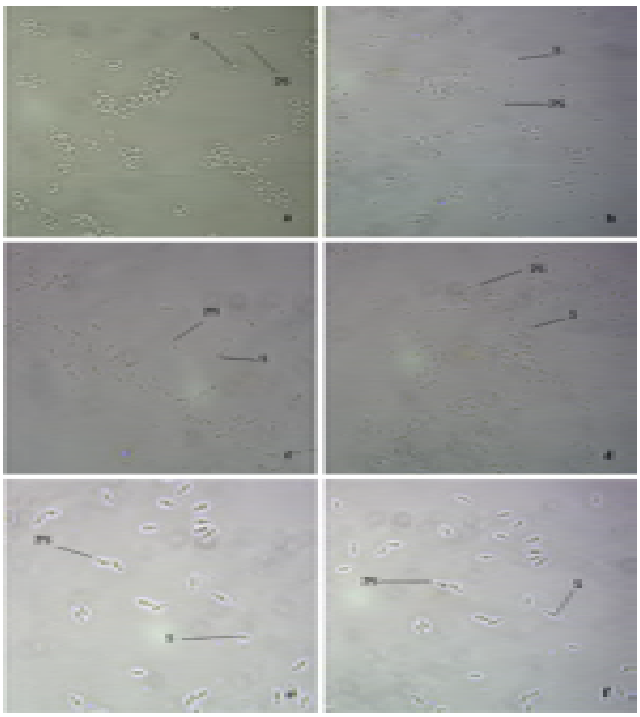


Fig. 3.3. The photomicrographs of *Paenibacillus sp* isolated from infected grubs of endemic areas of white grubs infestation of PDVVPSK Ltd sugar factory (a: BP1, b: BP2, c: BP3, d: BP4, e: BM and f: BR), Note: S: Sporangia, PS: Paraspore

Utilization of entomopathogenic nematodes against white grubs infesting sugarcane

Soil sampling was conducted in white grub affected sugarcane field (cv. CoM 10001) grown at Loni village area. A native Entomopathogenic nematode (EPN) species was recovered from soil samples using insect-bait technique and EPN killed Galleria were dissected in ringer's solution at an interval of 24 h to study morphological characteristics:

First-generation hermaphrodite female observed after 48 h of EPN infection. The observed morphological characters *viz*., presence of median and slit like vulva, reflexed ovaries, pointed tail with post anal swelling *etc* (Fig. 4A). Second generation amphimictic females and males observed after 72-96 hrs of EPN infection. The observed characteristics *viz*., presence of amphidelphic ovaries, hatching of eggs inside body of female, and males have bursa. Based on these characteristics, isolated native strain identified as *Heterorhabditis* spp. (Fig. 4B-C). With molecular techniques, a partial sequence of (805 bp) generated and deposited into NCBI GenBank database (Accession No. MN882612). NCBI-BLAST query revealed the isolated EPN was *H. indica* and designated as IISRBCCH02 isolate.

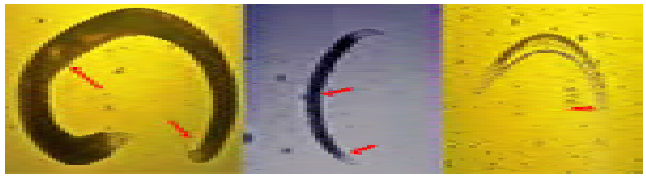


Fig. 3.4. Various stages of *H. indica* inside the dead Galleria. (A) First generation hermaphrodite female with median vulva, pointed tail with post-anal swelling, (B) Second generation female with amphidelhic ovaries and pointed tail, (C) Second generation male with distinct bursa at tail (Magnification 40X).

Activity: 1 Mass multiplication and field release of egg parasitoid, *Trichogramma chilonis* against borer complex of sugarcane

An egg parasitoid *T. chilonis* is employed for efficient management of borer complex in sugarcane (early shoot, internode and top shoot borer). The egg parasitoid was reared on its natural insect host (rice mealworm, *Corcyra cephalonica*) in laboratory and good qualities of green trichocards were distributed to farmers. Total 1643 tricho card strips were prepared and 535 tricho strips were distributed to the farmers.

Activity: 2 Transfer of technology/ Demonstration/Technology assessed

A total of 22 IISR light-pheromone (combo) traps (IISR technology) were distributed to the sugarcane growers in seven villages *viz*., Rajuri, Mamdapur, Babhaleshwar, Lohgaon, Loni and Chinchpur. These traps were installed in the month of May and collection of the adult beetles was monitored regularly. White grubs species recorded *viz*., *H. serrata*, *H. consanguinea*, *Phyllognathus dionysius*, *H. fissa*, *Anomala* spp., *Adoratus* spp. *etc*. During the 2019 crop season, a total of about more than 10,000 beetles were collected in these 22 traps.

Establishment of Biological Control Laboratory for mass production of bio-agents against insect-pest and diseases and dissemination of technology for enhanced cane and sugar productivity of Maharashtra

Under the RKVY scheme, Govt. of Maharashtra approved and sanctioned the project during the 23rd State Level Sanctioning Committee (SLSC) meeting under the chairmanship of Chief Secretary of Govt. of Maharashtra to IISR-Biological Control Centre, Pravaranagar. Land-lease registration document, land-lease deed MoU with sugar mill, *Gav Namuna Sat* 7/12, plot demarcation certificate, and all the other required documents were submitted to the RKVY office, Pune. The architectural plan, section and elevation of the Biological Control Laboratory has been finalized. RKVY office, Pune has submitted the request letter to Under Secretary, RKVY Cell, Mumbai, for release of first instalment of ₹ 3.30 crore which is yet to receive.

CHAPTER 4

Research in Plant Physiology and Biochemistry

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

Four organic compounds (GA_3, IBA, 6BA and NAA) were evaluated for their impacts on sugarcane biomass dynamic during the crop growth cycle. Two experiments were conducted for screening of effective dose of the compounds for their application in field experiment. An experiment under controlled conditions was conducted with six doses (35, 50, 70, 100, 150 and 200 ppm) of GA_3, IBA, 6BA and NAA each along with water, *Ethrel* and absolute control (under CRD). Sugarcane setts (CoLk 94184) were soaked overnight in the aqueous solution of GA_3, IBA, 6BA and NAA. The setts were planted on the following day in pots placed under glass house conditions (Fig. 4.1). Based on observation on H-A transition during the germination phase till 45 DAP and germination % , maximum impact of GA_3, IBA, 6BA and NAA was observed @ 50 & 100 ppm. Two doses @ 50 & 100 ppm of each compound were thus carried forward for their field evaluation in order to confirm their effect on sett germination and biomass dynamics during the crop growth cycle.

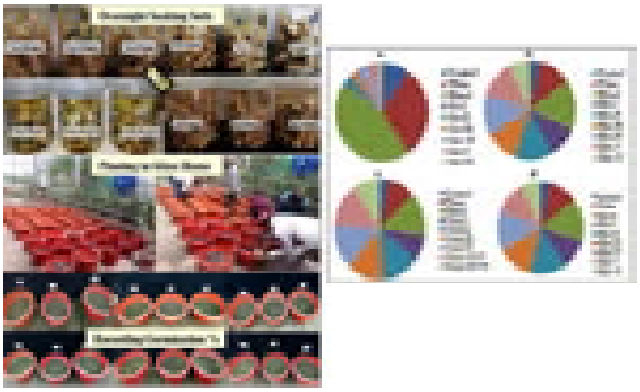


Fig. 4.1. Screening of varying concentrations of GA_3, IBA, 6BA and NAA for early and improved germination

Note: I, II, III, IV, V and VI indicate concentrations of GA_3, IBA, 6BA and NAA @ 35, 50, 70, 100, 150 & 200 ppm

A field experiment was initiated in Feb 2019 with two doses of GA_3, IBA, 6BA and NAA each along with water, *Ethrel* and absolute control using CoLk 94184 as test crop (Fig 4.2). HA transition, initial plant numbers, tiller numbers and biomass accumulation till 210 DAP indicated that maximum improvement in germination and biomass dynamics occurred with NAA. The germination % in decreasing order of NAA @ 50 ppm > *Ethrel* @ 100 ppm > control > NAA @ 100 ppm > 6BA @ 50 ppm > IBA @ 50 ppm > IBA @ 100 ppm > water > GA_3 @ 100 ppm > 6BA @ 100 ppm > GA_3 50 ppm at 45 DAP. Average initial shoot numbers were highest with water (85,000 shoots/ha) followed by NAA@50 and 100 ppm at 90 DAP with 69,265 and 62,777 shoots/ha, respectively against 60,462 shoots/ha with *Ethrel*. The biomass accumulation pattern remained same till 180 DAP however at 210 DAP, there was decline in number of tillers with NAA at both concentrations. *Ethrel* surpassed biomass accumulation against all compounds at all concentrations. Tiller numbers/ha were found to be in decreasing order of 175462, 148425, 1,43,057, 1,37,499 shoots/ha with *Ethrel* @ 100 ppm, IBA @ 50 ppm, NAA @ 50 & 100 ppm against 1,05,333 and 1,26,851 shoots/ha with control and water, respectively.

Fig. 4.2. Field experiment initiated in Feb 2019 with two doses of GA_3, IBA, 6BA and NAA each

Note: I, II, III, IV, V and VI indicate concentrations of GA_3, IBA, 6BA and NAA @ 50 and 100 ppm

Other biometric traits *vis a vis* cane length (Fig. 4.3), girth, internodal numbers, internodal weight, number of roots, root length, number of root hairs (Fig. 4.4) and cane weight 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*+ GA_3, followed by solo *Ethrel* and solo NAA @ 50 & 100 ppm with 1,68,240, 1, 38, 332, 1,18, 795 plant numbers/ha, 848.08, 728.01, 689.09 gm/cane, 125.33, 99.59 & 77.69 t/ha, respectively till 260 DAP. The experiment still stands in field for recoding of data till harvest stage.

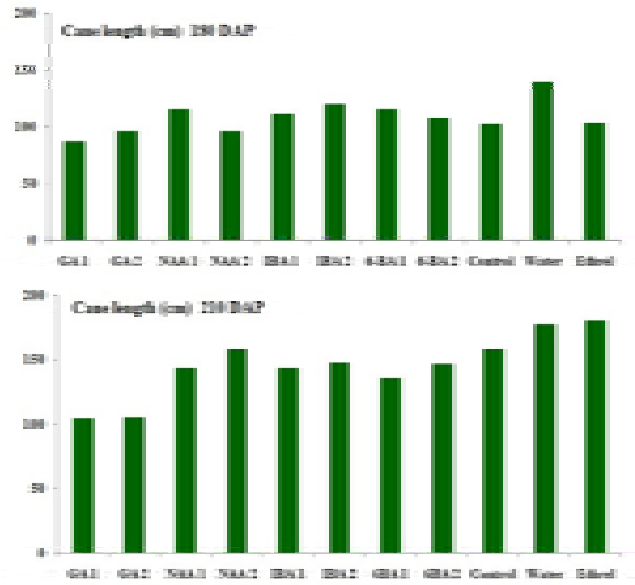


Fig. 4.3. Impact of varying concentrations of GA_3, IBA, 6BA and NAA on cane length (cm) at 180 & 210 DAP.

Note: 1 and 2 indicate conc. of GA_3, IBA, 6BA and NAA @ 50 (1) & 100 (2) ppm.

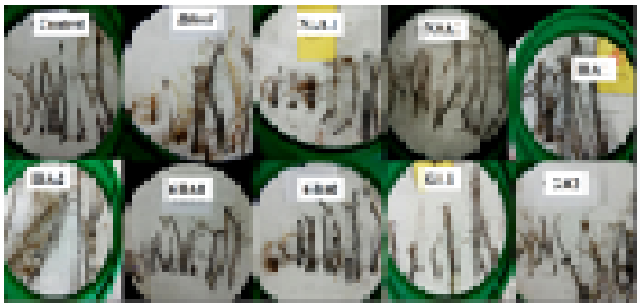


Fig. 4.4. Impact of varying concentrations of GA_3, IBA, 6BA and NAA on root properties at 120 DAP

Note: 1 and 2 indicate concentrations of GA_3, IBA, 6BA and NAA @ 50 (1) & 100 (2) ppm.

Effect of *Ethrel*, NAA and foliar spray of GA_3 on physiological efficiency of sugarcane ratoon crop: A field experiment was conducted to assess the effects of phasic application of *Ethrel* + GA_3 along with NAA (solo) on the stubble bud sprouting and crop biometric traits in sugarcane ratoon crop in varieties CoLk 94184, CoLk 09204, CoLk 09202, Co 0238. NAA rendered significant increase in sprouting % as well as the ratoon crop biometric traits. The highest yield of 154.95 t/ha was obtained with *Ethrel* + GA_3 followed by solo *Ethrel* (101.74 t/ha) and solo NAA (92.73 t/ha) in CoLk 94184 against control (71.68 t/ha). Ratoon yield was observed to be 142.82 t/ha with *Ethrel* + GA_3 followed by 105.46 t/ha with solo *Ethrel* and 85.95 t/ha with solo NAA against control (68.06 t/ha) in CoLk 09202. While the ratoon crop yield of 140.79 t/ha with *Ethrel* + GA_3 104.4 t/ha with solo *Ethrel* and solo NAA (81.75 t/ha) against control (65.70 t/ha) was recorded with CoLk 09204, lowest cane yield of 128.82 t/ha was obtained with *Ethrel* + GA_3 followed by solo *Ethrel* (82.91 t/ha) and solo NAA (71.62 t/ha) against control (58.06 t/ha) in Co 0238. It was concluded that *Ethrel* + GA_3 application led to maximum increase in ratoon crop yield irrespective of varieties.

Demonstration of PGR Technology using sugarcane varieties CoLk 09204, CoLk 09202 and CoLk 94184 : A demonstration with sugarcane varieties CoLk 09204, CoLk 09202 and CoLk 94184 was conducted under spring season for assessing the impact of exogenous phasic application of *Ethrel* and GA_3 on germination %, initial plant population and physiological efficiency. In spring planted crop at 210 DAP, the hormonal interventions manifested in cane weight of 139.20 t/ha in CoLk 94184, 137.76 t/ha in CoLk 09204 and 140.20 t/ha in CoLk 09202. There was significant increase in biomass accumulation with phasic application of *Ethrel* and foliar spray of GA_3 throughout the growth cycle irrespective of varieties (Fig. 4.5, 4.6 and 4.7).

Fig. 4.5. Impact of exogenous application of *Ethrel* + GA_3 on germination and shoot numbers

Fig. 4.6. Impact of exogenous application of *Ethrel* + GA_3 on cane height and crop growth

Fig 4.7. Impact of exogenous application of *Ethrel* + GA_3 on internodal length and crop growth

Minimizing post-harvest sucrose deterioration and its molecular assessment in sugarcane

Post-harvest deterioration of cane quality was assessed using four sugarcane varieties (CoLk 94184, CoLk 09204, CoPK 05191 and Co 0238) especially when these are harvested late in months of May and June. At the time of harvest (zero time), Brix % in cane among these varieties ranged from 19.57 to 22.32, sucrose % juice from 16.10 to 19.54 and purity from 76 to 90.21 (Figures 4.8, 4.9, 4.10). Post-harvest deterioration of cane was recorded after 11 days and at that point of time, Brix % increased to 26.55 (Co 0238) and sucrose dwindled to 9.70% (CoLk 09204). Decrease in sucrose % juice was also observed in other three varieties (Fig. 4.8). When chemical formulation (BKC+SMS) was applied immediately after harvest, deterioration of cane in terms

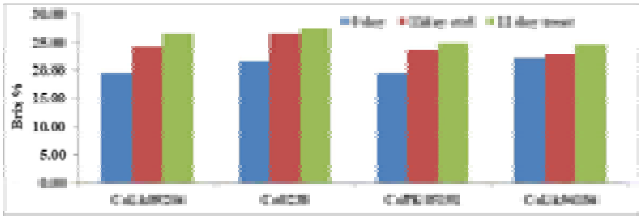


Fig. 4.8. Brix measured at zero and 11 days after harvest in control and SMS+BKC treated canes

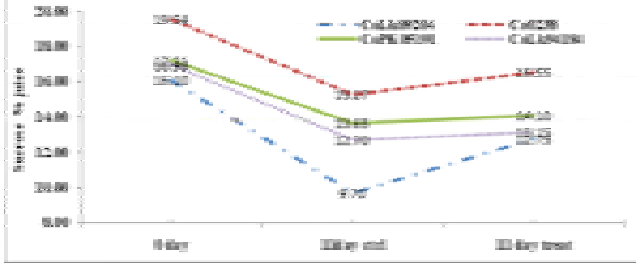


Fig. 4.9. Sucrose % juice measured at zero & 11 days after harvest in control & SMS+BKC treated canes

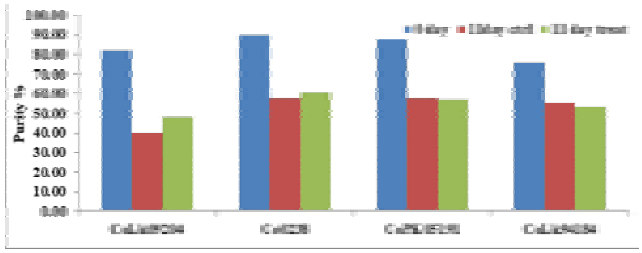


Fig. 4.10. Purity measured at zero and 11 days after harvest in control and SMS+BKC treated canes

of sucrose % juice as measured after 11 days of exposure was visualized reasonably less in comparison to untreated canes. After 11 days of harvest, sucrose % juice decreased to 9.7 from 16.1 in CoLk 09204, 15.27 from 19.54 in Co 0238, 13.65 from 17.21 in CoPK 05191 and 12.70 from 16.96 in CoLk 94184, however, this decrease was 12.75, 16.55, 14.10 and 13.5%, respectively when canes were exposed to BKC+SMS just after harvest. Maximum deterioration (after 11 days) in terms of sucrose % juice was observed in CoLk 09204 (39.8%) and minimum in CoPK 05191 (20.7%). Though chemical formulation has reduced the level of cane deterioration even in cane harvested late in month of May/June, its impact was only 2.1 to 6.6% among three early maturing varieties namely CoLk 94184, CoPK 05191 and Co 0238. Delayed crushing has significantly decreased the cane weight from 23 to 32% among these four varieties (11 days post harvest).

Quality deterioration of over-stand cane: A chemical formulation comprising of invertase inhibitor and growth promoters was used to check the quality of over-stand canes. Deterioration in terms of Brix % and sucrose % juice was assessed in four promising varieties of sugarcane (CoLk 94184, CoLk 09204, CoPK 05191 and Co 0238) when these were harvested late beyond May. Formulation was applied on over-stand cane and observations were recorded after 15 days of application in late May and early June. Due to chemical application, deterioration in general was observed less in terms of sucrose % juice over control. Most responsive variety to formulation was CoPK 05191 wherein deterioration was almost 3.2% less than those of control (Fig. 4.11). Brix % increased in almost all the varieties when these varieties were left in field beyond May and in fact formulation

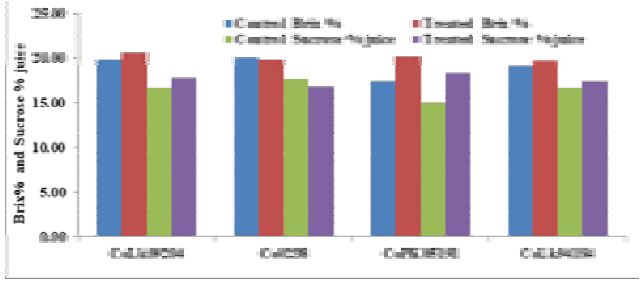


Fig. 4.11. Brix and sucrose % juice in over-stand canes (control and treated canes)

has not shown any reasonable response towards Brix change which has increased in over-stand cane during the course of experiment.

Genome sequencing of red rot pathogen of sugarcane

Genome of a virulent pathotype (*Cf* 08) of *C. falcatum* causing red rot to sugarcane was sequenced using Pac Bio (RSII) platform and almost 97.24% genome was covered. Raw reads were submitted at NCBI as SRA SRR8375625-SRR8375634 under Bioproject PRJNA509540. After assembly, a total of 238 contigs were observed and submitted as SWKJ00000000 at NCBI. A total of 18,635 protein-coding genes were predicted. Functional annotation of red rot pathogen genome revealed different classes of genes having important role in plant-pathogen interaction (Fig. 4.12). The genome sequences were compared with other fungal species which revealed that *C. falcatum* is closely related to *C. graminicola* and *C. higginsianum* the causal organisms of anthracnose in maize and Brassicaceae. Quiver polished draft assembly screened out a mitochondrial sequence of 27.72 Kbp. Enzyme code distribution analysis indicated all six classes of enzymes predominantly by hydrolases type (Fig. 4.13).

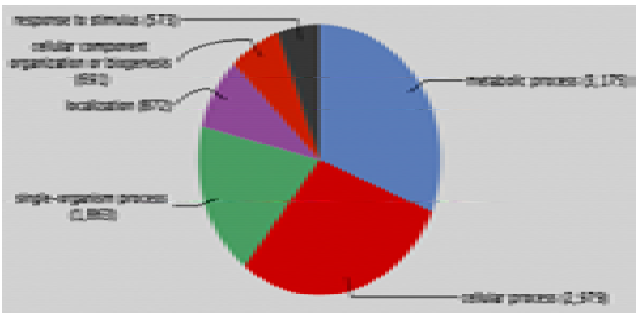


Fig. 4.12. Distribution of annotated genes involved in biological processes

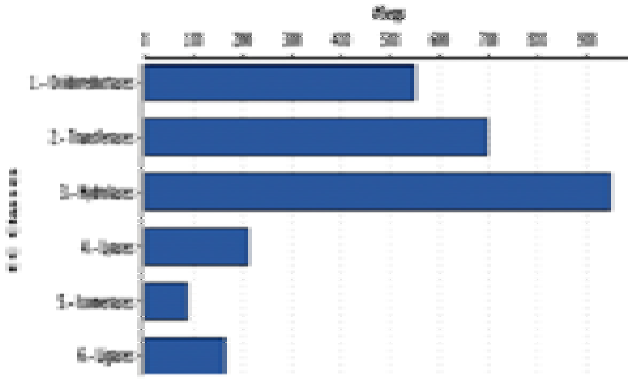


Fig. 4.13. Number of sequences belonging to different classes of enzymes in red rot pathogen (*Cf* 08)

Physiological and molecular bases of multiple abiotic stress tolerance in sugarcane

To study the physiological traits associated with single/multiple abiotic stress tolerance, field and pot culture experiments were conducted. In field trial, eleven genotypes (CoLk 94184, BO 91, CoS 767, CoJ 64, CoLk 12204, CoLk 07201, LG 04439, LG 03040, A-46-11, A-27-12 and UP 9530) were evaluated for tolerance to drought, waterlogging, and to their combinations. As compared to control, the cane weight (kg/clump) of genotypes decreased 13 to 38% in drought, 10 to 24% in waterlogging and 21 to 44% in combined treatment of drought and waterlogging. Under combined stress, the highest cane weight was recorded in CoLk 94184 followed by CoS 767, while CoJ 64 had the lowest. A significant positive correlation was found between chlorophyll stability index (CSI) of genotypes and tolerance index (% cane weight stress/control) under different stresses; these results were found consistent with pot experiment. In pot culture experiment, tolerant (CoS 767) and susceptible (CoJ 64) varieties were subjected to drought, waterlogging, and to their combinations under normal and saline soil conditions. Results indicated a significant variation in different growth parameters *viz.*, plant height, single cane weight, internode length, cane girth, leaf area, leaf fresh weight, root weight and volume under different stresses for both of the varieties. The lowest relative single cane weight for both varieties was found under combined stress of drought and waterlogging under saline soil conditions; being higher for CoS 767 than CoJ 64. The leaf K concentration dropped below the critical deficiency level under all single/combined stresses except for CoS 767 under drought and waterlogging. Na/K ratio showed an increase under salinity, drought+salinity, waterlogging+salinity and drought+waterlogging+salinity (Fig. 4.14). These results suggest that maintenance of high leaf K concentration may be one of important traits for multiple abiotic stress tolerance. The root tissue density for both the varieties was the highest under drought and the lowest in waterlogging. Under combined stress of drought+waterlogging+salinity, CoS

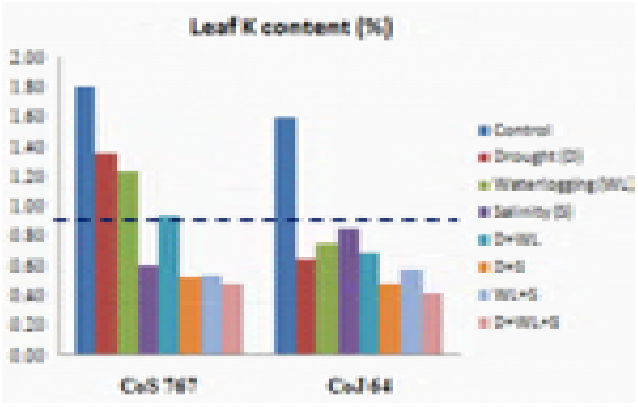


Fig. 4.14. Leaf tissue K concentration of CoS 767 and CoJ 64 under single/multiple abiotic stresses
Dash line above bar show the critical deficiency level of K in sugarcane (0.9%).

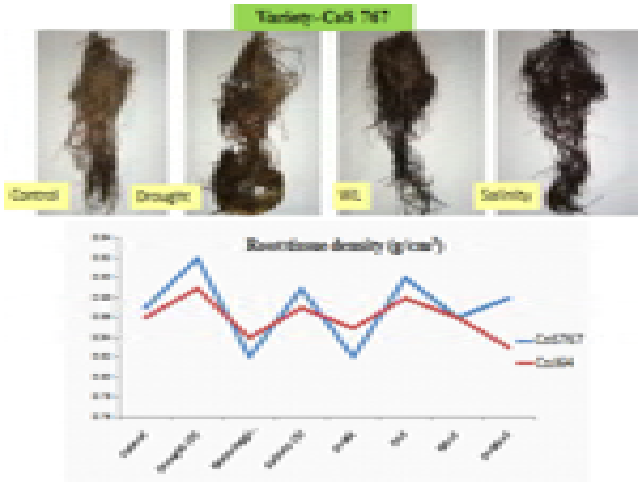


Fig 4.15. Root tissue density of CoS 767 and CoJ 64 under single/multiple abiotic stresses

767 had the highest root tissue density than CoJ 64 (Fig. 4.15).

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

Twelve varieties of sugarcane viz., CoLk 11206, CoLk 09204, Co 0238, Co 05011, CoLk 9709, CoLk 8001, CoLk 8102, CoPk 05191, CoLk 94184, BO 91, CoJ 64, CoPant 97222 were evaluated for their performance related to germination, vigour, dry matter partitioning and juice content. Planting of sugarcane was done during spring season 2019. Significant variations were recorded with respect to these traits which will be utilised for further characterisation at early stage of sugarcane growth. Germination was recorded from 19.3 (Co 0238) to 28.7 (Co Pant 97222) percent on bud basis. Maximum plant population was recorded in CoLk 8001 at 120 DAP. Maximum cane length at 180 DAP was achieved by CoLk 09204 (218 cm) and the lowest by CoLk 9709 (169 cm). The highest single cane weight was recorded for CoLk 8001 (866 g). Chlorophyll content was maximum in CoLk 8001 while minimum in CoLk 11206. Dry matter partitioning (180 DAP) revealed that CoPk 05191 attained maximum root mass per cane followed by CoLk 11206 while maximum leaf weight per cane was achieved by Co 0238 and CoLk 09204. Juice analysis in the month of November revealed sucrose content in the range of 11.04 to 14.23%.

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

Sugarcane variety CoLk 11206 was grown in field and silica treatment was given as basal (Soil placement) and foliar spray twice at 90 and 120 DAP. Two forms of silica *i.e.* silicon dioxide and silicic acid were used at 100 and 200 kg Si per hectare. Planting of sugarcane was done in spring 2019 following recommended agronomic practices. Silica when applied at 200 kg Si/ha as silicic acid in soil recorded significantly higher (23%) germination as compared to control (19.5%). Preliminary data indicates that silica treatment improves leaf sheath and root dry weight. Biometrics data (200 DAP) revealed minor variations in cane length, girth and single cane weight due to silica treatment. Juice analysis in the month of November didn't show any significant change in Brix and sucrose value.

Effect of *Jeewamrutha* treatment on sugarcane yield and juice quality

An experiment was conducted using CoLk 11206 to evaluate the effect of *Jeewamrutha* on yield and juice quality of sugarcane planted in autumn 2018 and *jeewamrutha* treatment was foliar spray in July, 2019 coinciding with grand phase of crop growth. *Jeewamrutha* treatment improved single cane weight from 641 to 785 g. No significant change was recorded for cane length, diameter and number of internodes. Higher Brix value of juice was recorded in treated canes (19.09) as compared to control (18.37), and sucrose was 16.3% (treated) and 15.65% in untreated canes. Cane dry weight was relatively higher while, leaf and root dry weight was reduced in *Jeewamrutha* treatment. This indicates *Jeewamrutha* treatment as foliar spray may have some beneficial effect on dry matter mobilization during active growth of sugarcane.

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

Sugarcane trash, a lignocellulosic component of sugarcane can serve to an efficient feedstock for ethanol production, along with, B heavy molasses. In order to achieve the objective of developing chemical pre-treatment processes for enhanced delignification of sugarcane trash, compositional analysis of sugarcane trash & B-heavy molasses was analysed. B-heavy molasses were obtained from sugar mill located in Shahjahanpur, UP, while sugarcane trash was procured from ICAR-IISR, Lucknow farm. The analysis was carried out for parameters related to 6 and 5 C sugars and is given in Table 4.1.

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

Soil analysis of waterlogged affected soil

Soil data obtained indicated reduced PH, organic matter, availble nitrogen and higher EC, P_2O_5 and K_2O

Table 4.1. Composition of sugarcane trash and B-heavy molasses

	Constituents			
	Sugarcane trash (dwb.)		B-heavy molasses (dwb.)	
1	Cellulose	43-45%	Total solids	21-32%
2	Hemicellulose	38-42%	Moisture	65-71%
3	Lignin	16-18%	Total dissolved solids	25-30%
4	Total sugars (Acid pretreated trash)	36-51%	Total sugars	25-28%
5	Reducing sugars (Acid pretreated trash)	23-37%	Reducing sugars	28%
6	Total N	-	Total N	0.62-0.98%

dwb: Dry weight basis

content in waterlogged affected soil as compared to control plot (Table 4.2).

Morphological changes and gene expression analysis in response to waterlogging

Morphological studies and gene expression analysis of four sugarcane genotypes CoLk 94184, BO 91, CoS 767 and CoJ 64 using total RNA of leaf tissues were performed after 30 days of waterlogging. Results indicated increased plant height of waterlogged plants, while, leaf area and SPAD index decreased markedly. The earlier appearance of aerial rooting as found, seems to be associated with greater root injuries. In leaves, the transcript of PFP enzyme (phospho fructokinase) which is involved in glycolytic reactions was upregulated in two varieties (90.5% in CoLk 94184 and 2.9% in BO 91) but downregulated in others due to waterlogging. In waterlogged plants, CYP81D8 (ROS related proteins) gene showed relevant increase (+110% in CoLk 94184) and BO 91 (13.6%) but slightly decrease in CoS 767 (-7.7%) and CoJ 64 (-5%). P_5CS involved in proline biosynthesis is slightly increased under waterlogged condition. SOD, an antioxidant enzyme increased significantly due to waterlogging; the highest increase

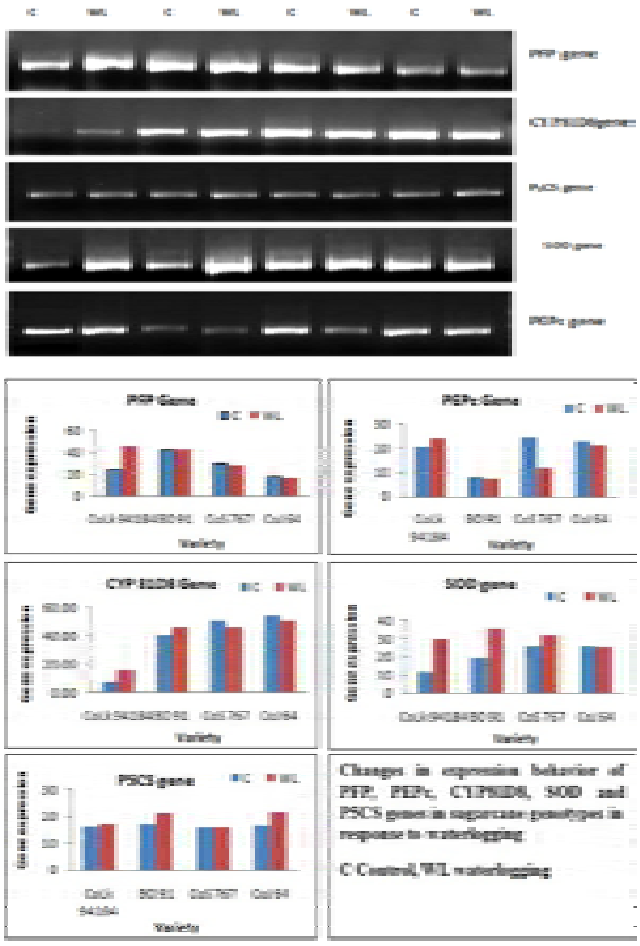


Fig. 4.9. Changes in expression behaviour of PEPC, PFP, CYP81D8, P5CS and SOD genes in sugarcane genotypes in response to waterlogging

(+154%) was observed in CoLk 94184 variety. PEPc, one of the CO_2 fixing enzymes produces oxaloacetate from PEP and HCO_3 is downregulated in leaves of waterlogged affected plants except in variety CoLk 94184 (Fig. 4.9). Expression analysis of these genes exhibited strong correlation with shoot and leaf attributes.

Table 4.2. Soil analysis of control and waterlogged plots

Soil plot with	pH	EC	% organic matter	Available nitrogen (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
Waterlogged ratoon crop	8.08	0.28	0.26	100.4	80.4	510.22
Waterlogged plant crop	8.09	0.29	0.27	125.5	71.23	378.72
Control plant crop	8.55	0.18	0.37	138.09	29.15	231.44
Control ratoon crop	8.40	0.18	0.28	138.09	27.54	236.70

CHAPTER 5

Mechanization of Sugarcane Farming

Development of two row disc type ratoon management device with and without stubble shaving attachments

Cultural operations such as stubble shaving, off barring and fertilizer application are recommended to be performed after harvesting for raising good ratoon crop of sugarcane. For carrying out these operations simultaneously in single pass, a new machine was developed. Main feature of the machine was its off barring discs which perform efficiently even in the field having left over surface trash. Developed prototypes were of two types. First was without stubble shaver- to perform off barring and fertilizer application. The second prototype has stubble shaver attachments also to perform stubble shaving along with off barring and fertilizer application (Fig. 5.1). Prototype without stubble shaver is suitable for piecemeal harvesting. Further field trials were conducted for evaluating the performance of both prototypes. Effective field capacity of the machine was 0.35-0.40 ha/h.

Development and evaluation of tractor operated multipurpose tool frame with attachments for sugarcane

Testing and demonstration of developed prototype at farmers' field

Prototype of developed multipurpose tool frame with furrow opening attachment was demonstrated at farmers' field in 1.0 ha area in Biswa Sugar mill area for furrow opening for planting of sugarcane using IISR deep furrower. Trapezoidal furrows were formed having top width of 32 cm and bottom width of 18 cm. The depth of furrow opened was observed 22-25 cm. The field capacity of the machine was 0.26 ha/h with field efficiency of 70%. The farmers were very much convinced about the depth achieved with this machine as compared to conventional ridger where only 10-12 cm depth of furrows was achieved (Fig. 5.2).

The IISR multipurpose tool frame with interculturing attachment was also demonstrated at farmers' field in different villages of Biswa Sugar mill area for interculturing operation in sugarcane crop (Fig. 5.3 and 5.4). Machine tines/shovel was adjusted as per the crop spacing. The machine was used in more than 20 hectare area at 34 farmers' field for inter-row interculturing operation. Machine was used for interculturing after 50-60 days of planting. The field performance of the machines is given in Table 5.1.

Fig. 5.2. Demonstration of multipurpose tool frame for furrow opening mode at farmers' field

Fig. 5.1. Two row disc RMD with stubble shaving attachment

Table 5.1. Performance results of the machine demonstrated at farmers' field

Parameter	Value
Height of the crop (mm)	500-600
Speed of operation (km/h)	2.6
Depth of interculturing (mm)	90-110
Weeding efficiency (%)	78.2
Inter-row tilled width (mm)	450-500
Untilled width during interculturing (mm)	200-300
Effective field capacity (ha/h)	0.44
Field efficiency (%)	76.0
Cost of operation (₹/ha)	1360

The machine has a provision of operation in combination mode for inter row interculturing, intra-row herbicide spraying and fertilizer application in a single pass.

Fig. 5.3. Operation of machine for interculturing in sugarcane at farmers' field

Fig. 5.4. Demonstration of machine for interculturing in sugarcane at farmers' field

Development of cane node planter

Prototype of manual cane node cutter was developed for cutting of cane nodes from whole seed cane (Fig. 5.5). Tractor operated cane node planter was field tested at ICAR-IISR farm (Fig. 5.6). 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 of the machine. Metering mechanism, comprising of lugged ground wheel driven belt and mild steel L shape cells, performed satisfactorily. Effective field capacity of the planter was 0.15-0.18 ha/h.

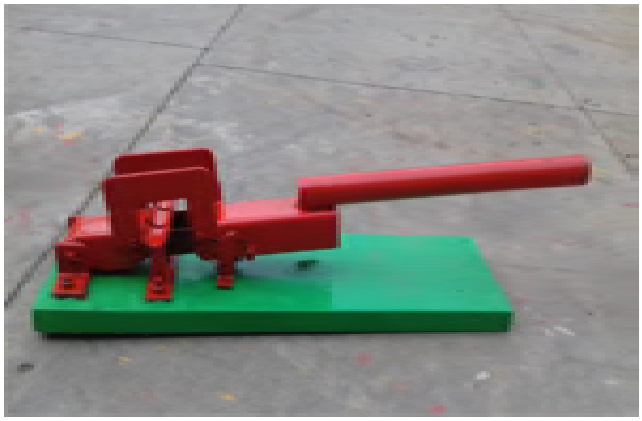


Fig. 5.5. Manual cane node cutter

Fig. 5.6. Tractor operated cane node planter in field operation

Development of sugarcane trash management machinery

Commercially available trash shredder and mulcher are used for trash management particularly for cereal crops. There is need for a new machine which could perform ratoon initiation operations as well as trash management in sugarcane. At ICAR-IISR, Plant Residue Shredder was developed. Limited field trials were also conducted. The performance was satisfactory for dry trash but there were problems during shredding of trash with high moisture content. Development of a

new machine has been conceptualized for trash management in sugarcane ratoon crop. The fabrication of main frame work and stubble shaving units has been completed. Fabrication work of the remaining components of the prototype is in progress.

Testing and evaluation of selected IISR sugarcane machineries under tropical condition

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. 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 (Fig. 5.7). It could be operated by a 30 kW power tractor. It was a mounted type equipment rigidly attached with tractor through three-point linkage. 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-Indian Institute of Sugarcane Research, Lucknow and supplied to ICAR-Sugarcane Breeding Institute, Coimbatore for conducting its field adoptability trials in tropical region.

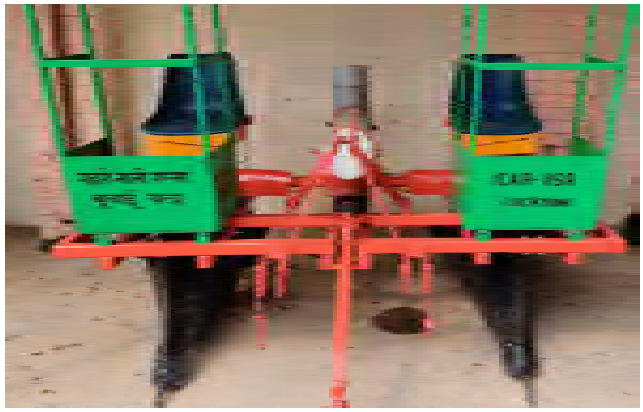


Fig. 5.7. Developed prototype of tractor operated wide spaced deep furrow sugarcane cutter planter

Prototype of disc type ratoon management device (Disc RMD) was modified. Fertilizer metering mechanism was modified to make it suitable 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 fertiliser at root zone. Modified prototype of Disc RMD was fabricated in the Workshop of ICAR-Indian Institute of Sugarcane Research, Lucknow and supplied to ICAR-Sugarcane Breeding Institute, Coimbatore for conducting its field adoptability trials in tropical region (Fig. 5.8).

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

AICRP on Farm Implements and Machinery (FIM)

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

Prototypes fabricated

S. No.	Name of the prototype	Achievement
1.	IISR TO deep furrow spacing sugarcane cutter planter with adjustable row spacing of 75/90 cm	1 No.
2.	IISR TO deep fertilizer deep furrow sugarcane cutter planter with deep fertilizer placement and adjustable row spacing of 75/90 cm	1 No.
3.	IISR TO wide spaced deep furrow sugarcane cutter planter with adjustable row spacing of 90/120/150 cm	2 No.
4.	IISR TO customized deep furrow sugarcane cutter planter with marker attachment	4 No.
5.	IISR TO double bottom adjustable row spacing deep furrow opener	5 No.
6.	IISR TO deep furrow sugarcane cutter planter-cum- raised bed multi crop seeder	1 No.
7.	IISR TO sugarcane trench planter-cum-potato planter	1 No.
8.	IISR TO single row disc type ratoon management device (Disc RMD)	1 No.
9.	IISR manual multi-crop seed drill	2 No.
Total		**18** (T.O. -16, Manual- 2)

Prototypes supplied

S. No.	Name of prototype	Number	Supplied to
1.	IISR TO wide spaced deep furrow sugarcane cutter planter with adjustable row spacing of 90/120/150 cm	1	ICAR-Sugarcane Breeding Institute, Coimbatore
2.	IISR TO single row disc type ratoon management device (Disc RMD)	1	ICAR-Sugarcane Breeding Institute, Coimbatore
3.	IISR TO customized deep furrow sugarcane cutter planter with marker attachment	1	Genda Singh Sugarcane Breeding Research Institute, Seorahi, Kushinagar (Regional Centre of UPCSR, Shahjahanpur)
4.	TO double bottom adjustable row spacing deep furrow opener	1	Genda Singh Sugarcane Breeding Research Institute, Seorahi, Kushinagar (Regional Centre of UPCSR, Shahjahanpur)
5.	IISR TO customized deep furrow sugarcane cutter planter with marker attachment	1	Regional Centre, Muzaffarnagar (Regional Centre of UPCSR, Shahjahanpur)
6.	TO double bottom adjustable row spacing deep furrow opener	1	Regional Centre, Muzaffarnagar (Regional Centre of UPCSR, Shahjahanpur)
7.	IISR TO customized deep furrow sugarcane cutter planter with marker attachment	1	UP Council of Sugarcane Research, Shahjahanpur
8.	TO double bottom adjustable row spacing deep furrow opener	1	UP Council of Sugarcane Research, Shahjahanpur
9.	IISR TO customized deep furrow sugarcane cutter planter with marker attachment	1	Seed Multiplication Centre, Gola, Lakhimpur Kheri (Seed Production Centre of UPCSR, Shahjahanpur)
10.	TO double bottom adjustable row spacing deep furrow opener	1	Seed Multiplication Centre, Gola, Lakhimpur Kheri (Seed Production Centre of UPCSR, Shahjahanpur)
11.	IISR TO deep furrow spacing sugarcane cutter planter with adjustable row spacing of 75/90 cm	1	Mahayogi Gorakhnath KVK, Gorakhpur
12.	IISR TO Single row disc type ratoon management device (Disc RMD)	1	Mahayogi Gorakhnath KVK, Gorakhpur
	Total	**12**	

UPCAR project "Centre of Excellence in Farm Machinery"

Testing of developed manual multicrop planter

Manual multicrop planter was tested at farmer's field in Biswa Sugar mill area of Sitapur district in November 2019 for sowing of chickpea, lentil and peas as intercrop in sugarcane which was planted at row spacing of 90 cm with IISR sugarcane cutter planter in October 2019 (Fig. 5.9 & 5.10). Two persons were required for operating the machine. The seed metering was through PVC vertical rotors having grooves on the periphery. There was no missing hill observed and in case of chickpea and peas, every grooves/cell picks only one seed and drops it perfectly. The effective field capacity of the machine was 0.10-0.11 ha/h with field efficiency of 63-65% (Table 5.2). Farmers appreciated this manual machine for sowing of intercrops in sugarcane.

Fig. 5.9. Demonstration of machine at farmers' field in Sitapur district

Fig. 5.10. Manual multicrop planter in operation for sowing intercrops in sugarcane

Table 5.2. Performance of multicrop planter for sowing of intercrops in sugarcane

Particulars	Observed values		
Crop	Chickpea	Pea	Lentil
Date of sowing	02.11.2019	03.11.2019	05.11.2018
Average speed (km/h)	1.8	1.9	1.8
Depth of seed placement (mm)	55	56	45
Line to line distance (cm)	90	90	90
Actual seed rate observed (kg/ha)	18	20	10
Effective field capacity (ha/h)	0.10	0.11	0.10
Field efficiency (%)	63	65	63
Cost of operation (₹/ha)	770	694	770

Development of sugarcane manual stripper cum detopper

During preliminary testing of the developed prototypes of manual stripper cum detopper, it was observed that the Model III having weight 225 g was found the best with the highest number of cane stripped and de-topped in a given time by both male and female farm workers. The further testing of these developed prototypes is going on at the Institute farm. The male and female farm workers having experience of cane harvesting were used for this purpose. After harvesting of cane, data of cane stripping and de-topping with all these tools by the different operators will be collected and analysed.

Development of weed cleaner for weed management

The developed prototype of manual weed cleaner was modified by changing its main pipe which acts as a reservoir for herbicide solution (5 litre) with a CPVC pipe of 150 cm length and diameter of 3.3 cm with no reservoir (Fig. 5.11). In new prototype, the cleaner was attached with a separate tank of 15 litre capacity which will act as a reservoir for herbicide solution and it was kept on the back of the operator while in operation. The herbicide solution was supplied from this tank to the spongy roller with a pvc pipe of 8 mm through a ball valve. The ball valve was attached for controlling the flow of herbicide solution to the spongy roller. The technical specifications of the new prototype of weed cleaner are given in Table 5.3.

Fig. 5.11. Modified version of manual weed cleaner

Table 5.3. Technical specifications of manual weed cleaner

Particular	Value
Effective working width (mm)	200
Main pipe length & outside diameter (mm)	1520 & 33
Roller width & diameter (mm)	210 & 95
Length of pipe and dia. (mm) above the roller	210 & 16 (4 small holes of dia. 0.8 mm)
Capacity of the tank (litre) and weight (empty) (kg)	15 & 3.5
Weight of the wiper (kg)	2.6
Tentative cost of the wiper (₹)	2500/-

Development of solar powered manual sprayer

A prototype of solar powered manual sprayer was developed for spraying herbicide/fungicide in various crops (Fig. 5.12). Preliminary testing of this sprayer has been carried out at Institute farm for spraying pre-emergence herbicide. One person is required to operate the sprayer. The sprayer has seven flat fan nozzles and effective width of sprayer is 3.6 meter. The height of spraying can be adjusted from 300 mm to 1,000 mm. The sprayer has two 12 V battery having 8Ah capacity and two pump of voltage 12V, 5.09 kgf/cm^2 pressure and 3.1 l/min flow rate. A 20 W solar panel was used to operate the pump. The effective field capacity of the sprayer was 0.5 ha/h and it takes two hours to cover one hectare area. The sprayer was found three times cost effective as compared to knapsack sprayer used by the farmers.

Fig. 5.12. Developed prototype of manual sprayer

CHAPTER 6

Diversification and Value-addition in Sugarcane

Refinement of sugarcane cleaner cum washer for jaggery

In order to further increase the speed of upper roller of second set of scrapping rollers, the sprocket of 24 teeth mounted on upper scrapping roller of 1st set has been replaced by sprocket with 32 teeth. In this way, the speed of upper roller of 2nd set of scrapping rollers would be doubled. Due to movement of all scrapping rollers with different speed, better scrapping action is expected. Secondly, 1 h.p. motor has been replaced by 2 h.p. motor. This was done to accommodate more canes for improving cleaner capacity. The machine is in the process of evaluation.

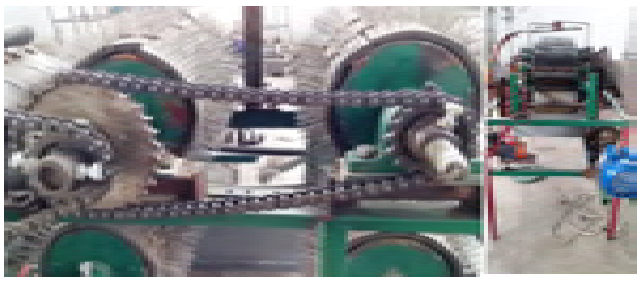


Fig. 6.1. Sugarcane cleaner-cum-washer with changed sprocket and 2 h.p. motor

Development of a jaggery furnace with efficiency boosting device

For scale up model of efficiency boosting device, a web of 50 mm pipe with nipples of 25 mm has been made. It has provision of air supply from one side through a blower. All nipples are fixed in such a manner that the exit air is directed towards pan bottom. It would be fixed in existing IISR 2-pan furnace. Performance evaluation of furnace having efficiency boosting device would be carried out by water boiling test as well as actual jaggery making.

Development of integrated drying system for jaggery drying

Dimension of collector has been worked out as 1.4 m length and 0.60 m width. Wood and glass have been selected for entire casing and air heating chamber, respectively. Base insulator thickness for the collector has been calculated as 3.45 cm. Solar absorber of the collector was proposed by using 0.55 mm corrugated iron sheet, painted black and mounted in a box of the same area.

Externally funded project

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

Soybean (*Glycine max*) was taken as a natural source of protein for addition to jaggery. It was mixed in three forms *viz*. whole soybean powder, soybean paste with and without seed coat. Varying quantities of all forms of soybean were added to sugarcane juice after the clarification process using vegetative clarificant during juice boiling and concentration. Jaggery thus prepared was moulded in one inch cubes. The samples were analyzed for quality parameters and protein content. Protein content of samples with soybean is shown in Fig. 6.2.

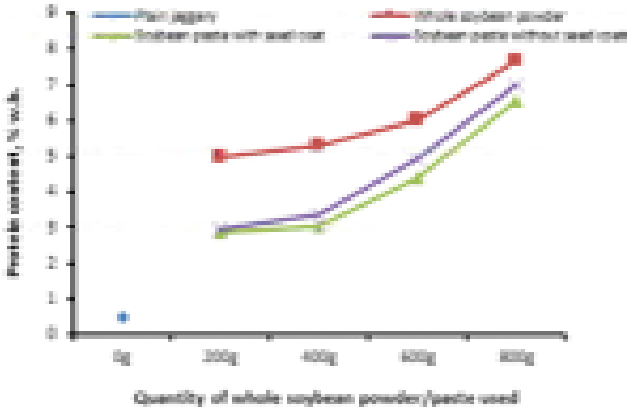


Fig. 6.2. Protein content of different jaggery samples

It may be seen from Figure 6.2 that protein content of jaggery increased with quantity of soybean added. Maximum protein was found with 800 g soybean powder (7.67%). This was due to addition of soybean in absolute form. More protein was found in case of soybean paste without seed coat as compared to with seed coat. All samples showed substantial increase in protein content when compared with plain jaggery.

CHAPTER 7

Developing Sugar Beet Varieties Suitable for Indian Agro-climates

Maintenance and multiplication of sugar beet germplasm

One hundred and twenty two genotypes are being maintained in the year 2019-20 at ICAR-IISR, Lucknow, out of which 80 genotypes have been planted at Mukteswar for seed production. Furthermore, in the year 2018-19, five different crosses were attempted for high sucrose and root yielding variety for sub-tropical conditions. In future, more crosses will be attempted to develop high sucrose yielding and, insects and diseases resistant varieties for sub-tropical conditions.

Morphological assessment of sugar beet grown under normal and drought conditions

The experiment was laid out in RBD with fifteen treatments and one check, *viz*., LS 6, in three replications with the aim of identifying sugar beet having good growth and yield under drought conditions in comparison to normal conditions. Morphological results showed that LKC LB, LKC 2007, LKC 2010, LKC 2006, LK 4, IN 5 and LKS 10 had the highest single root weight against check variety under normal conditions, whereas under drought conditions, thirteen varieties, *viz*., LKC LB, LKC 2000, LK 4, LKS 10, IN 5, IN 13, IN 15, LKC 2000, LK 27, LKC LB, LKC HB, LKC 2010, LKC 2007 showed high superiority against check variety. Genotypes LK 27, LKC 2000, IN 15, IN 13, IN 5, LKS 10, LKC 2000, LK 4, LKC 2010, LKC 2007 recorded higher root length under normal conditions but under drought conditions, LKC LB, LK 27, LKC 2000, IN 15, LKC 2006, LKC LB, LKC 2000, LK 4, LKS 10, IN 4, IN 5, LKC HB, LKC 2010 showed superiority over the check. Five varieties, *i.e.*, LKC 2010, LKC 2007, LKC 2006, LKC LB and LKC 2000 recorded root width superior to check variety LS 6 under normal condition while under drought conditions, LKC HB, LKC 2010, LKC 2006, LKC LB, LK 4, LKC 2000, LKS 10, IN 5, IN 15, LKC 2000, LK 27 and LKC LB recorded the higher root width against check variety. For leaf weight per crown, all the varieties showed superiority against LS 6 variety while under drought conditions, LKC LB, LKC 2010, LKC 2000, LK 4, LKS 10, IN 5, IN 13, IN 15 and LK 27 showed the higher leaf weight per crown against check variety. All the varieties had the higher crown weight in comparison to check variety under normal condition but in drought, LKC 2007, LKC 2006, LKS 10, IN 15, LKC 2000, LK 27 and LKC LB showed better performance than check variety.

Juice quality assessment of sugar beet grown under normal and drought conditions

Quality assessment of the above mentioned fifteen varieties against LS 6 (check) was done for high sucrose content under drought conditions. Results revealed that LKC 2000 and LKC 2010 recorded the highest sucrose content in sugar beet under normal condition while none of the variety showed better performance under drought conditions against check for sucrose content. LKC 2000, LK 27 and LKC 2010 showed better brix in normal condition against check varieties while IN 4, LK 27 and LKC 2006 were better in drought condition for this aspect.

CHAPTER 8

Economics, Statistics and ICT

Factors contributing sugarcane profitability and financial viability of sugar sector in India

The Indian sugar sector faced challenges due to extreme climatic conditions especially water scarcity, input cost, low organic carbon content and higher labour wages.

There are wide fluctuations in sugarcane productivity and stagnation in sugar recovery due to unfavourable climatic conditions such as low rainfall, drought, flood and water scarcity in Maharashtra during the last five years. The adoption of high sugar varieties, irrigation water saving techniques, sugarcane plantings, intercultural operations, mechanization, ratoon management, area increase in autumn planting, intercropping with short durational crops and wider adoption of mechanized trench planting are the factors contributing to sugar profitability. The area under early maturing sugarcane varieties has increased from 18.5 per cent to 87.3 per cent during the last five years in Uttar Pradesh. The key production constraints were sugarcane monocropping, low soil organic carbon, poor availability of quality seed cane, indiscriminate application of plant protection and chemical fertilizers and heavy infestation of white grubs in some part of Maharashtra. The majority of cane farmers do not apply FYM/biofertilizers and green manuring. The farmers should adopt integrated nutrient and pest management, trench, wider row spacing, cane seed and water saving techniques to enhance productivity per unit resources utilized to minimize cost of production, enhance income and improve profitability. The use of mechanical power in sugarcane cultivation has upward trends in Maharashtra and Uttar Pradesh as the application of machine for sugarcane planting, interculturing and ratoon management operations have improved over the years to address labour problems and wage issues. The cane farmers realized higher productivity and higher net income with adoption of Co 0238, CoLk 94184 in U.P., Co 86032 and Co M 265 in Maharashtra. They also adopted sugarcane cutter planter/trencher for crop planting, multi-purpose power tillers and rotavator for intercultural operations. Therefore, it is concluded that the inclusion of intercrops in sugarcane based farming systems enhances profitability, enriches soil health, supplements income and employment and ensures food and nutritional security.

Comparative economics of sugar production in Uttar Pradesh and Maharashtra

The sugar cost processing includes operational expenses such as sugarcane price, harvesting and transportation cost as well as overhead expenses incurred by the sugar mills and various conversion costs depreciation, interest paid on loans and other expenses incurred on sugar and other primary co-products processing for achieving food and energy security. The comparative cost of sugar processing in two major sugar producing states has been worked and presented in Table 8.1. This revealed that the cost of sugar production in comparing states varied from ₹ 3,403 to 3,512 per quintal in standalone sugar mills having crushing capacity less than 4,000 TCD. The integrated sugar-energy production units of more than 7,000 TCD have sugar production cost ₹ 3,270 to 3,230 per quintal in Uttar Pradesh and Maharashtra, respectively. Due to surplus sugar production and its excess supply in domestic as well global market led to decline in prevailing ex-mill sugar price ₹ 3,200-3,450 per quintal during year 2018-19 in an integrated sugar-energy complex owned by cooperative or private sector. The cost of sugarcane has a lion's share of 78 to 80% of total cost of sugar production in standalone sugar mills. The average cane crushing capacity of the surveyed sugar mills varied from 1,750 to 11,000 TCD in Uttar Pradesh and Maharashtra. The Daund Sugar Pvt. Ltd Mill, Alegaon (Pune) with capacity of 6,000 TCD achieved the sugar recovery of 11.29% with crushing duration of 148 days during sugar season 2018-19. The sugar mill has crushed 9.61 lakh tonne cane and produced 1.09 lakh tonne sugar. Besides, it, Padamshri Dr. V.V Patil SSK Ltd, Pravaranagar, (Ahmednagar) having crushing capacity of 5,000 TCD also obtained sugar recovery of 11.06% with crushing duration of 153 days during sugar season 2018-19. This sugar mill has crushed 9.92 lakh tonne cane and bagged 1.10 lakh tonne sugar. These sugar mills also diverted its B-heavy molasses for bio-ethanol production. Hence, their sugar recovery was low as compared to the last season. The DCM (Sugar) Pvt. Ltd. Mills in Uttar Pradesh also achieved sugar recoveries 11.70 to 12.25% during crushing season 2018-19. The integrated sugar- energy complexes used upgraded technologies and majority of respondent cooperative owned sugar mills had to increase crushing capacity, sugar recovery to make them economically viable, self reliant and competitive with efficient private sector sugar mills in Uttar Pradesh and Maharashtra.

Table 8.1. Economic analysis of sugar production in major producing states during 2018-19

(In ₹/quintal sugar)

Sl. No.	Parameter/Cost Component	Stand alone < 4,000 TCD		Sugar + Co-gen >4,000-7,000 TCD		Sugar + Distillery + Co-gen >7,000 TCD	
		UP	MS	UP	MS	UP	MS
1.	Sugarcane price	2764	2105	2676	1837	2618	1993
2.	Harvesting & transport	0	644	0	597	0	641
	Total sugarcane cost	2764	2748	2676	2433	2618	2634
3.	Power/electricity price	36	18	38	24	18	28
4.	Chemicals expenses	14	32	19	33	26	21
5.	Salary and wages	279	297	267	363	256	211
6.	Packaging	42	35	43	36	37	42
7.	Repair and maintenance	31	83	28	82	42	47
8.	Overheads	61	125	66	89	68	42
	Cash conversion cost	463	591	461	627	447	393
9.	Depreciation	33	42	34	64	57	36
10.	Interest on						
	Working capital	136	127	143	145	109	111
	Term loans	6	4	8	43	27	13
	Deposits	2	0	3	23	13	42
11.	Total interest	144	131	153	211	148	166
12.	Total conversion cost	639	764	648	903	652	595
	Cost of sugar production	**3403**	**3512**	**3324**	**3336**	**3270**	**3230**

The sugar recovery and production varies in sugar mills owned by cooperative or private sector. There are wide fluctuations in sugarcane supply to sugar mills during past four years which affect economic feasibility, profitability, cane price payment and outstanding cane price arrears on sugar mills. The integrated sugar-energy complex with more than 7,000 TCD capacity in Maharashtra have comparative cost advantage as compared to similar sugar complex in Uttar Pradesh as indicated in Table 8.1. Indian sugar sector has been facing problems of cyclic sugar production due to climate change and water scarcity. Keeping in view the current sugar production scenario, sugarcane processing should be diversified as per product market demand through creation of new innovative products and pathways of revenue generation for maintaining economic viability of sugar mills in sustainable manner. The probable options for diversification of sugarcane processing would be power co-generation, bio-ethanol production from B-heavy molasses or directly from cane juice, automation, establishment of agro-processing hubs by utilizing sugar mills infrastructural round the year, development of energy cane varieties for higher biomass and sugar. The Government of India has reviewed the progress of actual sugar exports made by the sugar mills against Minimum Indicative Export Quota (MIEQ) during 3rd quarter of the year 2019-20. To support sugar mills, appropriate policy have been adopted to reallocate un-exported MIEQ to those mills who have exported and are willing to acquire additional quota beyond the MIEQ of the last year. It will help in achieving the MIEQ target of sugar export of the year 2019-20. The Government of Maharashtra provides financial subsidy of ₹ 5,000 per tonne for sugar export promotion. To reduce sugar supply in domestic market and opening sugar stock for the next year, the Government has decided sugar export target of 5.0 mt for the year 2018-19. Besides of various policy measures and sops offered to the sugar mills, they exported nearly 3.5 mt sugar during the last season. To reduce the glut in domestic sugar market and to support mills to pay cane price to the farmers and clear cane arrears, the Government had announced variable price policy for bio-ethanol produced from final molasses, B-heavy molasses or directly from cane juice for optimizing sugar production and diversion of sugarcane for bio-ethanol production. The sugar mills would gain better returns from bioethanol as compared to sugar.

Economics of ethanol production from sugarcane juice, B-heavy and final-C molasses

As per new ethanol blending programme (EBP) policy 2018, bio-ethanol may supplement fossil fuels as the Government has fixed 10 and 20 per cent bio-ethanol blending targets with petrol by the year 2022 and 2030, respectively. As energy demand for transport and automobile sector is improving regularly, bio-energy manufacture from sugarcane can play a key role in achieving sustainability of Indian sugar mills in long run. The petroleum products demand is met through huge import of crude oil from different countries which leads to mammoth drain of foreign exchange for import bill payment. To maintain sugar prices and demand–supply equilibrium and to enhance bio-ethanol production, the Government of India announced differential price policy for bio-ethanol produced

through various routes like Final (C-molasses), B-heavy molasses or directly from sugarcane juice. The surplus sugar production during past few seasons led to low sugar price in domestic market. The sugar mills have to face economic hardship and some of them are running in losses due to high cost of sugar production and low revenue realization. The vapour thin profit margins led to accumulation of huge cane price arrears on sugar mills. To minimize sugar production, the Govt. of India has taken policy decisions and allowed diversion of B-heavy molasses and sugarcane juice for ethanol production during season 2018-19.

The Government of India maintained the differential prices for bioethanol production from various raw materials and declared premium of ₹ 54.27 and ₹ 59.48 per litre for bio-ethanol price produced from B-heavy molasses and directly from sugarcane juice, respectively as compared to bioethanol price of ₹ 43.75 per litre produced from Final C molasses through conventional route. Besides these incentives, applicable GST and transportation charges would be paid by the OMCs. The OMCs had given directives to give priority for bioethanol procurement produced directly from sugarcane juice, B-heavy molasses over final C molasses. Table 8.2 revealed that the bioethanol production through B-heavy molasses gave net income of ₹ 15.29 per litre to the distillery as compared to ₹ 12.68 per litre by conventional final molasses route. The minimum sugar price of ₹ 31,000 per tonne, declared by the Government was used to work out the economics of bioethanol production in integrated sugar-energy complexes. Sugarcane fair remunerative price (FRP) of ₹ 2,750 per tonne on base recovery of 10% declared by CACP for sugar season 2019-20 was applied to estimate economic returns and net profit from bioethanol production by using sugarcane juice. The diversion of B-heavy molasses for bio-ethanol production reduces sugar production by 13-15% and increase bio-ethanol production by 70-80%. The bioethanol production directly from sugarcane gives net income of ₹ 5.69 per litre to the distillery as compared to ₹ 15.29 per litre by B-heavy molasses. Therefore, the study concludes that the diversion of B-heavy molasses could be a potential option for enhancing sugar mills economic feasibility and bioethanol supply to mitigate 10% EBP targets by the year 2022.

The huge initial investment on distillery modernization and higher storage capacity are the key constraints in adoption of flexi sugar-bio-ethanol production plan by mill owners. The sugar mills have apprehension and they are in dilemma that the flexi production policy would sustain in long run during short supply of sugarcane. An integrated sugar-energy complex of 6,500 TCD has to adopt complete sugar-ethanol flexi production plan and divert whole sugarcane juice for ethanol production, it needs a modern distillery 500-650 KLPD capacity along with corresponding storage facility which requires additional financial outlay of approximately ₹ 600-700 crore. The diversion of B-heavy molasses for ethanol production would also reduce steam consumption in sugar, leading to bagasse saving, sugar colour and quality improvement; enhanced power supply to national grid from cogeneration. It would also contribute to packaging cost saving due to less sugar production. It would reduce burden on sugar stock, transport cost and minimize per litre effluent treatment cost to the integrated sugar-energy complex. Besides it, the Government has targeted to achieve initial target of 10 per cent ethanol blending with petrol by year 2022. The average ethanol blending

Table 8.2. Economics of Bio-ethanol production using sugarcane juice, B-Heavy and C molasses

Particulars/Economic parameters	Final C-molasses	B-heavy molasses	Sugarcane juice
Mill crushing capacity (TCD)	6500	6500	6500
Sugar recovery (%)	12.1	10.65	0
Molasses production (in % cane crushed)	4.5	6.5	0
Sugar production (t/day)	786.5	692.25	0
Molasses production (t/day)	292.5	422.5	0
Sugar price (₹/tonne)	31000	31000	31000
Sugarcane/molasses price (₹/tonne)	4500	8500	2750
Ethanol price (₹/litre)	43.75	54.27	59.48
Sugar production losses (tonne)	0	94.25	0
Sugar revenue losses (In ₹ in lakh)	0	29.22	0
Cost of cane/C molasses (In ₹ lakh)	13.16	13.16	178.75
B-heavy molasses price (In ₹ lakh)	0	35.91	0
Bio-ethanol recovery (litre/tonne)	230	365	70
Bio-ethanol production (litre/day)	67275	154213	455000
Revenue from ethanol (₹ lakh/day)	29.43	83.69	270.63
Raw material cost (₹/litre)	19.57	27.48	39.29
Conversion cost (₹/litre)	11.50	11.50	14.5
Cost of ethanol production (₹/litre)	31.07	38.98	53.79
Net profit to distillery unit (₹/litre)	12.68	15.29	5.69

of 8-9% with petrol may be achieved during 2019-20 as EBP targets in 10 major states in India. It is expected that out of total ethanol supply of 950 million litre, 290 million litre could be from B-heavy molasses/sugarcane juice.

Policy support for strengthening Indian Sugar Sector

- Need of integrated sugar-energy complexes for newer value added product diversification such as bio-manure, bio-CNG from press mud, filter cake, fly ash; bio-degradable plastics from bagasse, flavoured sugar and speciality sugar as per consumers demand to enhance revenue.
- High premium price for bioethanol produced from B-heavy molasses and sugarcane juice as an incentive to sugar mills for improving supply of bioethanol to achieve the targets of National Policy on Biofuels 2018.
- Encouraging sugar export through reduction in export tax. To improve economic viability of Indian sugar sector, decreased GST on ethanol from 18 to 5% and declared premium price to encourage product diversification for sustainable growth of Indian sugar sector.
- The Uttar Pradesh Power Corporation Limited (UPPCL) and UP Electricity Regulatory Commission (UPERC) have proposed to reduce power tariffs by 30-35% in the next few years for bagasse-based co-gen power supply to national power grid. The electricity tariffs of ₹ 6.19 to ₹ 6.75 per unit for the purchase of cogenerated power had reduced by ₹ 2.00 – ₹ 2.25 per unit, beleaguered sugar mills to face economic revenue loss of nearly ₹ 500 crore as annual power supply bill by sugar mills to UPPCL was approximately ₹ 1,500 crore. The new tariffs have been determined for captive and non-conventional energy generation unit (CRE) regulation, applicable on power co-generation from bagasse, biomass, solar plants *etc.*
- Making obligatory Minimum Indicative Export Quota (MIEQ) for sugar export promotion. Permission of 2.5 mt raw sugar and 5.0 mt refined sugar export under MIEQ scheme for sugar season 2018-19 to clear surplus stocks and improve cash flow to mills for cane price arrears payment.

Techno-economic feasibility of sugar beet cultivation for sugar and ethanol production

The economic feasibility of sugar beet cultivation *vis-a vis* its competing crop *i.e.*, wheat cultivation was carried out in Punjab. Net returns from sugar beet cultivation were more than double the returns obtained from rice or wheat cultivation. The sugar beet cultivation has increased the income levels of the growers. Analysis of comparative economics of wheat and sugar beet revealed that though the total cost of sugar beet cultivation (₹ 93,500 per ha) is almost double as compared to wheat cultivation (₹ 48,000 per ha), the net returns per ha were almost the double compared to wheat crop. The requirement for labour was four times higher as compared to just 16 man days required per ha for wheat. The eighty per cent farmers perceived that the sugar beet gave more return as compared to wheat. About 60% farmers were convinced that the sugar beet improved the land quality, while 40% were desirous of shifting away from the wheat crop. Sugar beet growers were generally having large land holding size. The average holding size was 19.5 acre per farm.

Impact assessment of IISR developed technologies

A study on impact assessment of Institute developed technologies such as sugarcane cutter planter, varieties developed and other production and protection technologies was carried out.

Impact of sugarcane cutter planter development: Since its inception, ICAR-IISR, Lucknow has developed various types of cutter planters to suit the different planting methods like deep furrow, trench and zero till planting. Sugarcane cutter planter is operated by small tractor (mostly 35 hp) and its field capacity was 0.2 ha/hr (or 1 ha in 5 hrs) with field efficiency of 80%. The planter plants 1.6 ha per day (8 hrs) on an average. It performs all planting operations as one operation and takes only 5 machine hours, along with some manual labour (4 person hours) for planting of cane in one ha. The planters have the provision for fertilizer and weedicide application too. The use of this planting machine eliminates manual seed sett cutting distribution and planting operation and results in the saving of 35 mandays per ha in the planting of cane, and therefore, the net saving by using the sugarcane cutter planter is ₹ 10,500 per ha. It has been found that the machine has good acceptability and its use results in reducing the labour requirement per ha and ultimately reduce cost of cane cultivation. The number of sugarcane cutter planters in operation in India has increased substantially in almost all the cane growing states of India. The sugarcane cutter planters have been purchased by all types of cane holdings. There are about 2.63 lakh cane growers who are using sugarcane cutter planters. These sugarcane cutter planters are also very popular with the small farmers cane growing holdings as the growers who are using these machines constitute 62.75% of the total users of the machine. Uttar Pradesh has the largest number of users followed by Tamil Nadu, Andhra Pradesh and Haryana. With these efficiency indicators, the extent of

cost reduction in sugarcane cultivation all India level was worked out to the extent of ₹ 182 crore. The machine is also good on equity considerations as about ₹ 103 crore is the saving on the farms of small holders. The returns to investment made in the development of sugarcane cutter planter were also worked out. The investments on research on sugarcane cutter planter were considered from the year 1968-69 to 2018-19 and the time series was deflated by using CPIIW. Benefits were considered as started coming from 1990-91. The analysis highlights that the present value of research investment on sugarcane cutter planter was to the tune of ₹ 85.89 crore and the present value of net returns obtained due to use of the machine were to the tune of ₹ 3014.05 crore. The investment for sugarcane cutter planter was found to be quite profitable at ₹ 35.1 per rupee invested in the development of the machine.

Analysis of cost of cultivation of sugarcane in Uttar Pradesh during 2019-20

The cost of sugarcane cultivation for central Uttar Pradesh region was estimated by carrying out survey of 20 farmers in Hardoi and Sitapur districts of the State. The overall cost of sugarcane production was estimated to be ₹ 286.60/q (₹ 301.20 plant crop and ₹ 271.90 ratoon crop) excluding loading and transport cost and ₹ 306.6/q (₹ 321.20 plant crop and ₹ 291.90 ratoon crop) when these components are included. The information so generated was presented in Uttar Pradesh State Sugarcane Price Fixation Meeting. The estimates of cost of cultivation of sugarcane for the sugarcane year 2018-19 (sugar season 2019-20) were provided to the Uttar Pradesh Cane Development Department as an advisory note.

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

A study for the development of district-level database on sugarcane growth and sustainability in India was undertaken with the objective of developing background information for the preparation of futuristic (by 2050) sugarcane crop planning. Trends in area, production and productivity of sugarcane at the district-level for the period 2007-08 to 2017-18 were worked out and provided to the working group constituted at the Council level. For the sustainable growth of sugarcane in the country, requisite focus for research and development strategy is needed not only at the state level but also at the district level so that the growth potential at more disintegrated level may got analysed by considering the bio-physical resources, agro-climatic conditions and the socio-economic conditions prevailing at the district level.

The information compiled district-wise was analysed and strategic distributions of the sugarcane growing districts in the states/country were worked out in terms of "the extent of area under sugarcane cultivation", sugarcane cultivation intensiveness in terms of "area under sugarcane cultivation as per cent of net sown area (NSA)", and "the sugarcane productivity levels". There are only 118 districts in the country where sugarcane is grown in more than 5000 ha area and sugarcane cultivation directly supports the sugar industry. Out of these, 81 districts, each are having 10,000 ha or more of sugarcane area (Table 8.3). Further, out of these 41 districts are having more than 25,000 ha of sugarcane area. Twenty five districts may be grouped as having more than 50,000 ha area, 12 districts as each having more than 1.00 lakh ha area, 5 districts as each having 1.50 lakh and 3 districts as each having more than 2.0 lakh ha area under sugarcane cultivation. Uttar Pradesh and Karnataka are having two and one district, respectively, which is having more than 2.0 lakh ha area under sugarcane. Out of 12 districts, each having more than 1.0 lakh ha area under sugarcane, 6 are in UP, 4 in Maharashtra and one each in Karnataka and Bihar. Out of 25 districts, each having more than 50,000 ha area under sugarcane, 13 are in UP, 6 in Maharashtra, 2 in Karnataka, and one each in Bihar, Uttarakhand, Gujarat and MP. Most of the individual districts in Tamil Nadu, AP, Telangana, Punjab and Haryana are not having more than 25 thousand ha area under sugarcane.

Table 8.3. Distribution of districts according to the extent of sugarcane area ('000 ha) in major sugarcane growing states in India

State	Number of districts		Distribution of districts according to the extent of sugarcane area ('000 ha)						
	Total	Cane growing	>5	>10	>25	>50	>100	>150	>200
Uttar Pradesh	75	75	42	29	22	13	6	4	2
Maharashtra	36	30	18	16	9	6	4	0	0
Tamil Nadu	38	30	10	4	0	0	0	0	0
Karnataka	30	23	8	6	2	2	1	1	1
Bihar	38	32	4	4	2	1	1	0	0
Punjab	22	16	5	3	0	0	0	0	0
Haryana	22	18	8	5	1	0	0	0	0
Uttarakhand	13	5	2	2	1	1	0	0	0
Gujarat	33	17	6	4	2	1	0	0	0
Andhra Pradesh	13	13	7	5	1	0	0	0	0
Telangana	33	22	1	1	0	0	0	0	0
Madhya Pradesh	55	51	4	1	1	1	0	0	0
Assam	33	27	2	0	0	0	0	0	0
Chhattisgarh	28	22	1	1	0	0	0	0	0
Total		420	118	81	41	25	12	5	3

The numbers of districts having higher extent of sugarcane cultivation as percentage of net sown area in the district (Table 8.4) are quite high in UP as compared to other states. In seven districts of UP, the sugarcane is cultivated by allocating more than 50% of net sown area (NSA), out of which, one district cultivates sugarcane upto the extent of more than 75% of its NSA. Uttarakhand

Table 8.4. Distribution of district sugarcane intensiveness as reflected by sugarcane area as per cent of net sown area

States	Distribution of districts according to the sugarcane area as percentage of net sown area in the district						
	<2%	2 - 5%	5-15%	15-30%	30-50%	50-75%	>75%
Uttar Pradesh	30	13	12	6	6	6	1
Maharashtra	14	6	9	0	1		
Tamil Nadu	14	8	7	1			
Karnataka	15	5	1	2			
Bihar	27	0	2	2	0	1	
Punjab	9	4	3				
Haryana	11	4	3				
UttaraKhand	1	0	2	0	0	1	
Gujarat	4	2	3	1			
Andhra Pradesh	8	3	2				
Telangana	18	0	1				
Total	151	45	45	12	7	8	1

and Bihar are also having one district each where sugarcane cultivation is quite intensive, in more than 50% of its NSA. Maharashtra is having one district where the sugarcane intensiveness is more than 30% but less than 50% of NSA. In 11 major cane growing states where sugarcane is grown in a sizeable area, 45 districts are growing sugarcane upto the extent of 2-5% of NSA, other 45 districts upto 5-15%, 12 districts upto 15-30%, 7 districts upto 30-50%, 8 districts upto 50-75%, and only one district having more than 75% of NSA

The distribution of districts according to sugarcane productivity levels is given in Table 8.5. At the district level, the sugarcane productivity is quite high in some districts compared to the national average. Ten districts of major cane growing states are having productivity levels of more than 120 t/ha, while 43 districts spread across 7 states are having productivity level of more than 100 t/ha. Around 10 districts having more than 120 t/ha productivity levels are in Andhra Pradesh, Tamil Nadu, Karnataka and WB. Forty three districts that have achieved more than 100 t/ha productivity level are in Tamil Nadu, AP, Maharashtra, WB, Karnataka and Punjab. In Uttar Pradesh, so far 14 districts are having 80 t/ha out of which 2 districts are having 90 t/ha productivity level. No district has yet crossed the 100 t/ha mark in UP. Collectively, around 123 districts in major cane growing states are having productivity level of more than 80 t/ha out of which 63 districts are having productivity level of more than 90 t/ha. In this manner, 254 districts are having sugarcane productivity levels of more than 60 t/ha.

Table 8.5. Distribution of districts in India according to sugarcane productivity levels

State	Number of districts having sugarcane productivity levels (t/ha)					
	>60	>70	>80	>90	>100	>120
Uttar Pradesh	58	37	14	2	0	0
Maharashtra	16	11	9	6	5	0
Tamil Nadu	29	29	26	19	17	1
Karnataka	21	19	15	10	5	2
Bihar	12	1	1	1	1	0
Punjab	16	16	11	4	1	0
Haryana	16	15	10	5	0	0
UttaraKhand	5	1	0	0	0	0
Gujarat	15	0	0	0	0	0
Andhra Pradesh	13	13	12	10	10	6
Telangana	22	20	7	0	0	0
Madhya Pradesh	2	0	0	0	0	0
Orissa	9	4	1	0	0	0
West Bengal	20	17	17	6	4	1
Assam	0	0	0	0	0	0
Chhattisgarh	0	0	0	0	0	0
Total	254	183	123	63	43	10

Development of web based reporting system for the trials of AICRP on Sugarcane

AICRP on Sugarcane conducts multi-location trials with a large network of diversified research centres generating a huge amount of data every year. It has been found that traditional system of data management in AICRP trials has inconsistent physical or digital format due to no or minimum use of modern data management tools. There are many data handling issues such as retyping of data, late reporting, wrong/missing data, and poor documentation, interpretation, decision support in this system. Managing non-digitized data takes more time for compilation, documentation and interpretation. It was recommended in AICRP Group Meeting to develop software for data management of AICRP trials.

A web based application, AICRP Reporter, has been developed to provide an effective data recording and reporting platform for AICRP on Sugarcane (Fig. 8.2). Software facilitates AICRP data profile management, observation recording, data analysis, report generation; security management and settings. A number of modules are available in the software for managing various profiles *viz.*, Project, Experiment, Centre, Official, Trial, Treatment, Character, Treatment Schedule, Character Observation Schedule, and Event/Activity, Remarks, *etc.* There are two methods of trial observation recording in the system *viz.*, through online data entry interface and through generation and uploading of excel files. AICRP Reporter facilitates generation of reports of Projects, Experiments, Trials, Officials, Centres, Characters, Treatments, Treatment Schedule, Character Observation Schedule, Observation, Events, *etc.*, in consistent format. Data analysis and reporting modules are available for documentation, interpretation and decision support.

Open source technologies have been utilized for development and hosting of the application. Java and JSP has been used for development of the software. Apache Tomcat web server hosts the application while MySQL server extends database support to it. User can access the software over the Internet using URL https:/

/iisr.icar.gov.in/iisr/aicrp/software/index.jsp from any standard web browser. Links of the software have been added in the website of ICAR-IISR, Lucknow and AICRP on Sugarcane. Software gives authenticated access using user-id and password, and therefore, AICRP officials need registration in the software for its accessibility. Further, accessibility is provided in various user roles of Project Coordinator, Principal Investigator, Centre Incharge, Investigator (Project Leader), Technical, Guest User for secured accessibility of AICRP database.

AICRP collected data of Zonal Varietal Trials for the year 2018-19 from its centres through this software using both online data recording and through excel file generation. Software is generic and may be replicated in other such crop environment with suitable changes.

Fig. 8.2. Home Page of AICRP Reporter

Online database and mixed model analysis of sugarcane varieties tested/released in India

Genetic improvement in CCS (t/ha) of sugarcane clones tested under AICRP(S)

Genetic improvement in economic yield is a key of success in breeding programmes of any crop. For effective monitoring of the programme at national or zonal level, it needs to be measured in quantitative terms at regular intervals. Under new zonal varietal trial in sugarcane, elite clones are being evaluated since 1998-99 in all the five sugarcane agro-climatic zones. In this study, attempts have been made to assess the impact of breeding programme on the genetic improvement in CCS (t/ha) in elite clones of sugarcane evaluated in zonal varietal trials conducted from 1989 to 2015 and to develop a mechanism for evaluating the efficiency of proposed programmes based on the estimated variance components. This will help in resource allocation in sugarcane variety evaluation programmes in our country and accordingly, we can modify our varietal development programme.

During 1989 to 2015, a total of 526 trials were conducted in five zones with different agro-ecological conditions under Crop Improvement programme of AICRP (S). Depending on number of locations in a zone, the highest number (126) of trials (30.42%) were conducted in Peninsular Zone followed by North West Zone (25.67%), North Central and North Eastern Zones (23.96%) and in East Coast Zone (19.96%). In all the zones, 256 (49%) trials were conducted in early maturity group and 270 (51%) in mid late maturity group. A total of 2311 elite clones were evaluated during 1989 to 2015. The highest number (39.81%) of clones was tested in Peninsular Zone followed by 26.18% in North West zone, 19.86% in North Central Zone, 10.30% in East Coast Zone and minimum (3.85%) in North Eastern Zone (3.85%).

The overall genetic improvement in Commercial Cane Sugar (t/ha) – CCS (t/ha) was found progressive as it was reported in cane yield in all the four zones during 1991 to 2015, *i.e.*, 4.28% during 1991 to 2000, 13.11% during 2001 to 2010 and 10.59% during 2011 to 2015 over the base period 1989 to 1990. It showed that progress in genetic improvement in Commercial Cane Sugar (t/ha) – CCS (t/ha) was reported as increasing. Similar progressive trend was observed in all the four zones *i.e.*, Peninsular Zone and North Central and North Eastern Zone, North West Zone and East Coast Zone under AICRP(S). The highest genetic improvement was observed in East Coast Zone during the period 2000 to 2015 in comparison to other three zones followed by North West Zone during same period. The lowest genetic improvement was observed in North Central and North Eastern Zone during 1990 to 2015 (Table 8.6).

The overall improvement in Commercial Cane Sugar (t/ha) – CCS (t/ha) was found from 9.08 to 10.59 (t/ha) in the country during twenty five years. In Peninsular Zone, it increased from 12.25 to 12.71 (t/ha). Similarly, it increased from 8.46 to 12.42 (t/ha) during the 25 years. In North West Zone, it increased from 6.73 to 9.10 (t/ha). In North Central Zone and North Eastern Zone, it increased from 8.44 to 13.86 (t/ha). Only negative improvement in CCS (t/ha) was found in North Central and North Eastern Zone during 1991-2000.

The genetic improvement in Commercial Cane Sugar (t/ha) was the highest as 46.81% in East Coast Zone during 27 years (1989 to 2015) followed by North West Zone (35.21%), Peninsular Zone (14.93%) and North Central Zone and North Eastern Zone (10.04%). Overall in the country, it was found as 16.63%. In recent

Table 8.6. Genetic improvement in CCS (t/ha) of sugarcane clones under All India Coordinated Research Project on Sugarcane

Year	Peninsular Zone	East Coast Zone	North West Zone	North Central and North Eastern Zone	Overall
1989-1990	11.25	8.46	6.73	7.67	9.08
1991-2000	11.61 (3.13)	11.59 (37.05)	7.74 (15.05)	6.61 (-13.86)	9.47 (4.28)
2001-2010	12.93 (14.91)	11.90 (40.69)	8.78 (30.49)	7.89 (2.82	10.27 (13.11)
2011-2015	12.71 (12.96)	12.42 (46.90)	9.1 (34.83)	8.44 (9.98)	10.59 (16.60)

Figure in parenthesis is per cent increase over average CCS (t/ha) of 1989 to 1990

years (2011 to 2015), the genetic improvement in Commercial Cane Sugar (t/ha) was found to be the highest in all the four zones. It can be concluded that the sugar productivity in the country is in increasing trend during last 25 years due to the research efforts of the ICAR-All India Coordinated Research Project on Sugarcane.

Efficiency of designs in sugarcane field experiments

The experiment was conducted according to an alpha lattice design with incomplete blocks with two replications, 21 cultivars, 3 blocks within a replicate and 7 plots per block in each replication. This arrangement of experimental units and blocks has been found to minimize variation within the block while maximizing variation among blocks. The randomization of 21 cultivars was done with Design Resources software of ICAR-IASRI, New Delhi. The cultivars were planted in plots with 6 m x 6 rows x 1.2 m (Gross) in each replication. The net experimental plot area was 45 m x 4 rows x 1.2 m (Net). The seed rate was 12 three budded setts per meter. The data of each plot were recorded for germination (30 days after planting), germination (60 days after planting), tiller (90 days after planting), tiller (180 days after planting), number of canes (210 days after planting), brix (%) at 300 days after planting and sucrose (%) at 300 days after planting. The data of each parameter was subjected to statistical analysis according to the technique of analysis of variance (ANOVA) for the alpha lattice design developed by Patterson and Williams (1976). The arrangement of treatments in alpha lattice into groups gave possibility of data analysis as a randomized complete block experiment as RBCD 1. A separate randomized complete block experiment as RBCD 2 was also conducted in the same field with two replications with same 21 cultivars as conducted in alpha lattice design. The data of each parameter was subjected to statistical analysis according to the standard technique of analysis of variance (ANOVA) for the randomized complete block experiment for RBCD-1 and RBCD-2. Lay out plan, randomization and statistical analyses of alpha lattice design and randomized complete block design were carried out through the computer software SAS 9.3.

The error mean squares from each analysis were used to estimate the relative efficiency of an alpha lattice design compared with RCBD.

An estimated relative efficiency (ERE) less than 1 indicates that RCBD is more efficient, while value nearly equal to 1 suggests that the two designs yield similar results. Value of ERE greater than 1 suggests that alpha lattice design is more efficient design than RCBD.

Relative efficiency of Lattice design compared with RCBD-1 increased experimental precision by 9.18 and 7.11 for germination (30 days after planting), germination (60 days after planting).

CHAPTER 9

All India Coordinated Research Project on Sugarcane

All India Coordinated Research Project on Sugarcane is providing research support for developing sugarcane technologies involving State Agricultural Universities, ICAR Institutes, State Govt. Departments and NGOs. The research programme pertaining to four disciplines *viz*., Crop Improvement, Crop Production, Plant Pathology and Entomology are implemented in five sugarcane growing zones in the country. There are 22 regular centres comprising 20 centres funded through AICRP on Sugarcane and two centres are ICAR Institutes. Besides, SAUs also participate voluntarily in implementation of technical programme of AICRP.

New programmes, *viz*., integrated application of organics and inorganics for improving soil health and soil productivity, zonal evaluation of varieties at wider row spacing in Peninsular and East Coast Zones, screening of varieties for yellow leaf and pokkah boeng diseases, management of borers through pheromones, methodology for grading resistance of varieties against major insect-pests and chemical control of early shoot borer were initiated. The physical and financial progress was monitored by the Project Coordinator and the Council. The physical progress is annually reviewed during Workshop/Group Meeting. The research programmes are decided according to the mandate and objectives of the AICRP on Sugarcane.

Mandate

- Evaluation of locally adapted sugarcane varieties with improved yield and quality as well as resistance to biotic and abiotic stresses
- Development of package of practices for higher cane sugar production
- Development of low cost technologies for sugarcane production
- Intensifying and extending the networking facility and information generation for transfer of technology to the farmers and sugar industry.

Objectives

- To coordinate and monitor multi-location testing of advance breeding materials for evaluating appropriate region/location specific improved varieties.
- To conduct strategic and applied research of inter-disciplinary nature for evolving appropriate region/location specific package of practices for crop production.
- To develop eco-friendly region or location specific strategies for management of economically important diseases and insect pests.
- Enhancement and maintenance of disease free nucleus seed material for distribution to the cooperating organizations.
- To disseminate generated information and technology.

I. Programme-wise Research Achievements

Crop Improvement

- **Identification of sugarcane varieties**

  Four sugarcane varieties *viz*., Co 12009 (Sankalp) in mid-late group from ICAR-SBI, Coimbatore for Peninsular Zone, Co 13035 (Karan 14) in mid-late group from SBI-RC, Karnal and CoS 12232 (Sahaj 3) in mid-late group from UPCSR, Shahjahanpur for North West Zone and CoC 13339 in mid-late group from SRS, Cuddalore for East Coast Zone were identified for release.

- **Zonal Varietal Trial:**

  A total of 25 Zonal Varietal Trials (12 in early, 9 in mid-late and 4 trials combining early and mid-late maturity groups) were conducted during the year 2018-19. There were 7 IVT and 18 AVT trials. A total of 42 entries in early group, 48 entries in mid-late group and 51 entries combining both the maturity groups were evaluated. Of these entries, 12 in early, 13 in mid-late and 9 entries with combined trial of early and mid-late groups were found to be promising.

- **Fluff Supply Programme**

During the year 2018-19, National Hybridization Garden (NHG) was planted with 595 parental clones out of which 404 clones (69.70%) flowered. Among 24 participating centres of Fluff supply/National Hybridization programme, 22 centres attended the crossing programme. A total of 125 female and 70 male parents were utilised by the participating centres. Co 86032 and Co 775 were the frequently used female and male parents, respectively.

Twenty two fluff receiving centres were facilitated to make 539 bi-parental, 14 poly crosses, 154 general collections at NHG, ICAR-SBI, Coimbatore. Nine centres utilized National Distant Hybridization Facility (NDHF) established at ICAR-SBI RC, Agali for making 32 bi-parental crosses and 30 general collections. Fluff weighing 26.86 kg of crosses made at NHG and NDHF during 2018 flowering season were supplied to the 22 sugarcane breeding centres of National Hybridization and Fluff Supply Programme.

Crop Production

- Addition of 20 t/ha FYM/compost along with inorganic fertilizers applied on the basis of soil test, soil test crop response for targeted yield or on the basis of general recommendation for the region has shown positive effect on sugarcane growth and yield both in plant and ratoon crops. Response of bio-fertilizers (*Azotobacter*/*Acetobacter*/*Azospirillum*/PSB) was more pronounced in peninsular zone.
- Planting of sugarcane in paired rows (120:30) with mulching of trash (6 t/ha) in the inter-row spaces out yielded the conventional flat method with or without mulch at all the centres in the North western, North central and North eastern zones. Being in the climatic region of high evaporative demand, sugarcane crop responded up to 1.0 IW/CPE irrigation regime in the zones, however, similar yields have been recorded with 0.8 IW/CPE ratios at many centres.
- Trash mulching could effectively save 20-26% irrigation water over no-mulching.
- Sugarcane crop in Peninsular and East Coast Zones responded to furrow planting (120 cm) and skip furrow irrigation combined with the use of leguminous crop as green manure till 75 DAP, as mulch during tillering and thereafter residue incorporation. As far irrigation regimes, IW/CPE ratio 1.0 was found to result in higher cane productivity, however, it can be restricted to 0.8 for getting higher water use efficiency in these zones.
- Use of mulch in sub-tropical zones and green manuring followed by mulching and residue incorporation resulted in tropical zones resulted in higher net return.
- Evaluation of AVT genotypes at wider row distance and high fertility levels showed significant loss of yield at wider planting across all the zones. Wider row spacing, however, helped enhancing single cane weight at several locations.
- Best performing early genotypes across the different zones were; *viz.*, North West Zones (Co 13034, CoPb 13181, CoS 13231) and North Central (CoSe 13451, CoP 13437, CoSe 13452) while mid-late genotypes were North West Zone (CoH 13263, Co 13035, CoLk 13204) and East Coast (PI 14377, CoC 13031). In Peninsular Zone, the best performing genotypes were Co 12009, Co 12012, CoM 12085, VSI 12121 found superior under early and mid-late categories.
- Long term weather data provided only by two centres (Lucknow and Nayagarh) indicated continuous reduction in rainfall in the North-West Zone combined with conspicuous increase in average annual minimum temperature (0.01°C).
- Moisture stress during pre-monsoon growth phase brought about significant reduction in cane yield across all the zones. The loss in yield ranged within 20 to 35% in different sugarcane growing zones.
- Sugarcane varieties found resilient against moisture stress in different sugarcane growing zones in early maturing *viz.*, North West Zone (CoPb 92, CoPk 05191, CoLk 94184); Peninsular (SNK 088789); North Central (CoP 16437, CoLk 94184) and East coast (CoOr 03151) while in mid-late maturing group, North West Zone (CoPb 94, Co 05011, CoLk 11206, CoSe 11453, CoH 119); Peninsular (Co 86032); North Central (CoP 2061) *etc.*

Crop Protection

Plant Pathology

- In Plant Pathology discipline during 2018-2019, eight experiments were allotted to 17 AICRP(S) centres in different sugarcane producing zones of the country.
- Differential host studies were conducted at 12 AICRP(S) centres in all the zones with 72 new isolates along with designated pathotypes on the 19 host differentials to identify variation in red rot. More number of pathogenic variants have been isolated from the popular varieties such as Co 89003, CoC 24, CoS 8436, CoSe 92423 and CoSe 95422. The new isolates behaved almost similar to the existing pathotypes, however, there is enough indication of emergence of new pathotype(s) from Uttar Pradesh and Haryana.
- Fifteen AICRP(S) centres have carried out red rot and smut testing, six for wilt and twelve for YLD resistance. Large number of entries were identified as R/MR to red rot, smut and wilt from all the four sugarcane producing zones.
- AICRP(S) centres recorded YLD resistance in the ZVT entries and reported moderate to severe

occurrences of YLD under field conditions on the popular sugarcane varieties.

- Survey for natural incidence of sugarcane diseases across the country revealed that red rot still continues to occupy prime importance in traditional sugarcane growing areas and there is also growing importance of smut in subtropical region of the country. Epidemic occurrence of red rot in few pockets in the subtropical region is of serious concern and there is a need to closely monitor emergence of new pathotypes from them. Prevalence of red rot has been reported in the tropical region at moderate level mostly in Tamil Nadu. In addition, occurrence of YLD, grassy shoot, wilt, rust, pokkah boeng and brown spot was recorded in different states of the country in varying proportions.
- AICRP (S) centres have evaluated ISH and IGH clones for red rot resistance.
- AICRP (S) centres have confirmed rust inoculation methods and also pokkah boeng epidemiology, tolerance in sugarcane varieties and fungicidal management.
- AICRP (S) centres have demonstrated the impact of YL disease on sugarcane by comparing virus-free and virus-infected seed canes with the farmers.

Entomology

- During the year 2018-19, six projects were conducted in entomology discipline of AICRP (S) at nine centres (regular and voluntary) under three different sugarcane producing zones of India.
- In North West Zone, out of all the genotypes/ varieties screened against major insect pests, highly susceptible ones were CoPb 14211, CoH 13263 against top borer; CoPant 13244, CoH 13263, Co 14185, Co 0238 against root borer; Co 13034, Co 05011, CoLk 13204, Co 0238 against stalk borer and Co 0238 against internode borer. Rest other genotypes/varieties were either less of moderately susceptible.
- In Peninsular Zone, genotypes/varieties *viz*., Co 12007, CoSnk 13106, CoSnk 05103, Co 15018, Co 15020, Co 15021, CoVC 15061, CoSnk 05103 were either less or moderately susceptible while rest all were highly susceptible against early shoot borer. In AVT (Ratoon), none of the genotypes were highly susceptible to early shoot borer. Against internode borer, all the genotypes were highly susceptible except CoSnk 15101, CoVC 15065, Co 86032. In AVT (Ratoon) except Co 12007, all the genotypes tested were either less or moderately susceptible to internode borer. All the genotypes were highly susceptible against mealy bugs except CoN 13072, Co 13009, Co 13014, Co 13020, CoC 671, VSI 12121. Genotypes/varieties *viz*., Co 13003, CoSnk 13101, Co 13006, Co 13008, Co 13009, Co 13013, Co 14005, Co 15002, Co 15007, CoSnk 15102, CoVSI 15121, Co 15009, Co 15010, Co 15015, Co 15017, Co 15020, Co 15021, CoN 15072, CoSnk 15104, CoVC 15061, PI 15132, VSI 15122, CoC 671 and CoSnk 05103 were highly susceptible against scale insects and rest others were either less or moderately susceptible. None of the genotypes/varieties was highly susceptible to *Pyrilla*, top borer and sugarcane woolly aphid.
- In East Coast Zone, none of the genotypes/varieties were highly susceptible to early shoot borer. Genotypes/varieties *viz*., CoV 15356, CoC 15336, CoC 15338, CoC 01061, CoA 92081, CoA 14323, PI 14377 and 93 A 145 were highly susceptible to internode borer and rest others were either less or moderately susceptible.
- High incidence of sugarcane insect pests *viz*., early shoot borer, root borer, internode borer, top borer, cut worm, white grub, scale insect, white fly, mealy bug, web mite, sugarcane woolly aphid, rusty plum aphid, thrips, black bug were reported from different parts of the country. Some uncommon insect pests *viz*., plant hopper (*Eoeurysa flavocapitata*), blister mite, whorl weevil were also reported. Invasive insect pest, Fall army worm (*Spodoptera frugiperda*) was reported on sugarcane from Andhra Pradesh and Tamil Nadu by RARS, Anakapalle and ICAR-SBI, Coimbatore.
- The bioagents, *viz*., *Telenomus dignus, Telenomus beneficiens, Isotima javensis, Cotesia flavipes, Rhaconotus scirpophagae, Encarsia flavoscutellum, Fulgoraesia (Epiricania) melanoleuca, Stenobracon deesae, Stenobracon sp. Tetrasticus pyrillae Encarsia flavoscutellum, Dipha aphidivora, Coccinella septempunctata, Cheilomenes sexmaculata* were found active against different pests in sugarcane.
- Mass multiplication of sugarcane bio-agents using cost effective techniques was done for *Trichogramma chilonis, Eumicrosoma* sp., *Chrysoperla zastrowi* sillemi, *Fulgoraecia melanoleuca, Beauveria brongniartii* and *Metarhizium anisopliae* for use against various insect pests.
- Low incidence of insect pests with higher yield and B:C ratio was recorded in IPM plots as compared to farmers' practice in all the experiments conducted by different centres.
- Waterless pheromone trap (Delta trap) was found better in catching moths of early shoot borer and internode borer over water basin pheromone trap. However, erratic results at few centres could be due to low natural population of the moths.

II. Technology developed

- Efficacy of ethrel (50 ppm) on accelerating and enhancing germination in sugarcane has been recommended.
- Application of FYM @ 20 t/ha + inorganics based on soil test basis for higher cane yield and NMC has been advocated.

Meetings Organized

Annual Group Meeting of AICRP on Sugarcane

The Annual Group Meeting of All India Coordinated Research Project on Sugarcane was hosted by the University of Agricultural Sciences, Krishinagar, Dharwad (Karnataka) during October 14-16, 2019. The inaugural session was started on October 10, 2019 and presided over by Dr. M.B. Chetti, Vice Chancellor, UAS, Dharwad and Dr. R.K. Singh, ADG (CC), ICAR; New Delhi was the Chief Guest. The inaugural session was attended by the scientists working on sugarcane at different centres located in five sugarcane growing zones in India. Dr. P.L. Patil, Director of Research, UAS, Dharwad welcomed the delegates and participants. Dr. A.D. Pathak, Director and Project Coordinator (Sugarcane), ICAR-IISR, Lucknow presented the Project Coordinator's Report and highlighted the varietal/ technological achievements/impact on enhancing sugarcane productivity and sugar recovery resulting in higher sugar production at the national level.

Recommendations (Plenary Session)

The plenary session was held on October 16, 2019. The Chairman invited Principal Investigators/ Rapporteurs for presentation of the proceedings of different technical sessions. The following recommendations were made:

- The breeders should include the name of the scientist who conducted the trial on Agronomy, Plant Pathology and Entomology under contributor/collaborator list in the proposal for release of sugarcane variety to Centre Sub-Committee on Crop Standards, Notification and Release of the varieties (CVRC/SCRC).
- Brain storming session should be organized on seed programme to produce disease free seed in sugarcane.
- For strengthening ARS, Sankeshwar centre, pathologist post may be created at ARS, Sankeshwar.
- Under crop production, new programme AS 75: Precision nutrient management through rescheduling time of application for widely spaced sugarcane plant-ratoon system will be initiated during crop season 2020-21.
- Data management modules should be created for Crop Production, Entomology and Plant Pathology in addition to Crop Improvement for reporting data of experiments through AICRP Reporter Software.
- Data of all the experiments under AICRP should be reported through AICRP(S) reporter software during crop season 2019-20.
- Strictly follow the guidelines for preparing the proposal of variety to be submitted for consideration in Varietal Identification Committee Meeting.
- Recommendation in the form of technologies to the farmers should be made in each discipline. During 2018-19, the following recommendations were emerged out:

Crop Improvement

- The varieties developed through AICRP (S) *viz.*, Co 10026 (Peninsular Zone), CoA 11321 (East Coast Zone), Co 12029 (North West Zone) and CoLk 12207 and CoLk 12209 (North Central & North Eastern Zones) were released for commercial cultivation.

Crop Production

- In sub-tropical region of the country, paired planting of sugarcane (30:120 cm) with trash mulching in inter pair spaces should be adopted to raise sugarcane yield and water productivity. Irrigation at IW/CPE ratio of 0.8 should be followed.
- In tropics, planting of sugarcane at 120 cm distance and sowing of green manure at 30 DAP for terminating at 75 DAP to cover the surface as mulch and then incorporation at 110 DAP should be adopted for higher cane productivity and water use efficiency at optimum IW: CPE ratio of 0.8.
- In order to improve soil health and add to soil carbon sequestration, mulching with sugarcane trash with or without *Trichoderma* should be followed.
- Irrigation water use efficiency (IWUE) could be increased up to 2,265.5 kg/ha-cm with fertigation of 100% recommended dose of nitrogen and irrigation water at 75% of pan evaporation.

Crop Protection

- Low incidence of insect pests with higher yield and B:C ratio was recorded in IPM plots as compared to farmers' practice in the experiments conducted by different centres. Therefore, IPM module based technology may be recommended to the farmers for adoption.
- Epidemic cycles of *Pyrilla perpusilla* are the serious problem in sugarcane growing areas. Therefore, mass multiplication technology of *Fulgoraesia (Epiricania) melanoleuca* may be advocated to the biological control laboratories in different research institutions.

Varietal Identification Committee Meeting

- Varietal Identification Meetings were held under the Chairmanship of Dr. R.K. Singh, ADG (Commercial Crop), ICAR, New Delhi on October 15, 2019 at UAS, Dharwad (Karnataka) during

Annual Group Meeting of AICRP (S). In the meeting, following four sugarcane clones were identified for release:

1. First proposal submitted by SRS, Cuddalore in mid-late group for identification of CoC 13339 (GC of Co 86032) was discussed. Its clone has cane yield (117-97 t/ha), sucrose per cent juice (18.21), CCS (15-16 t/ha) and Pol% in cane (14.48). The CoC 13339 showed superiority for yield, sucrose per cent in juice, CCS% and Pol % in cane by 14-81%, 2.48%, 18.53% and 5.39%, respectively over zonal check (CoV 92102). Reaction against red rot was moderately resistant to resistant. This clone was least susceptible to early shoot borer. The committee identified the CoC 13339 for East Coast Zone for release and further notification.

2. Second proposal submitted by UPCSR, Shahjahanpur in mid-late group for identification of CoS 12232 (Sahaj 3) was discussed. Area of adoption for this variety is North West Zone. This clone showed superiority for sugarcane yield (88.86 t/ha), CCS (11.21 t/ha), sucrose% in juice (18.18) and Pol % cane (14.12). Significant improvement in cane yield (9.74%) and CCS (11.21%) was observed as compared to 1st Zonal check CoPant 97222. However, the clone also showed superiority in sucrose % in juice (0.11) and pol % cane (1.29)

over CoS 8436 (2nd zonal check). The clone showed disease reaction of moderately resistant to resistant against red rot and resistant to smut. The committee identified CoS 12232 for release and notification in North West Zone.

3. Third proposal submitted by ICAR-SBI, Coimbatore in mid-late group for identification of clone Co 12009 (Sankalp). Area of adoption for the variety is Peninsular Zone. This clone recorded higher sugar yield of 17.31 t/ha at 360 days across the zone with an overall improvement of 10.40% over the best mid-late standard Co 86032. Co 12009 recorded cane yield of 119.65 t/ha which was 7.94% higher over zonal check CoSnk 05103 and was an excellent ratooner. The mean sucrose% juice of Co 12009 was 19.91. Reaction against red rot was moderately resistant to resistant and yellow leaf disease was resistant. The proposal was identified by the committee for release and notification in Peninsular Zone.

4. Fourth proposal submitted by ICAR-SBI, Regional Centre, Karnal in mid-late group for identification of clone Co 13035 (Karan 14). Area of adoption for the variety is North West Zone. The mean CCS yield of Co 13035 in North West Zone was 11.17 t/ha which was 11.70 and 8.66% higher over zonal standards CoPant 97222 and local release check Co 05011, respectively. The mean cane yield of Co 13035 in the zone was 87.86 t/ha. It exhibited 9.67% and 7.42% improvement over zonal standard CoPant 97222 and local release check Co 05011, respectively. Co 13035 was an excellent ratooner and least susceptible to shoot borer, top borer and stalk borer and moderately resistant to red rot disease. The proposal was identified by the Committee for release and notification in North West Zone.

Institute Research Project of AICRP(S) Unit

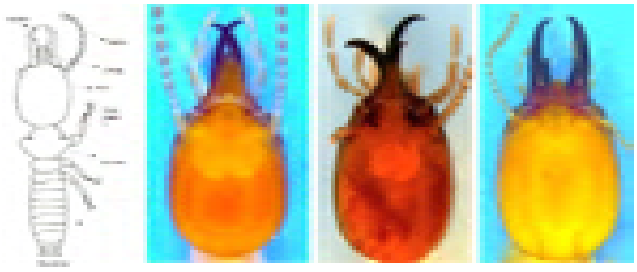
Development of eco-friendly technologies for the management of termites in sugarcane

Three new species of termites on sugarcane

Three species of termites *viz.*, *Odontotermes vaishno* Bose, *Odontotermes bellahunisensis* Holmgren and Holmgren and *Odontotermes horni* (Wasmann) were recorded for the first time feeding on sugarcane in different fields of ICAR-IISR Farm, Lucknow. The taxonomic identification was done with the help of taxonomist, Dr. Kalleshwara Swamy, C.M., College of Agriculture, University of Agriculture & Horticulture, Shimoga 577 201 (Karnataka). Major characters of soldiers were taken for identification purpose. Figures of all the newly recorded species are mentioned hereunder (Fig. 9.1).

Artificial diet for termites

In order to develop artificial diet for rearing of termites under laboratory condition, wood powder of 11 plants *viz.*, *Mulethi* (*Glycyrrhiza glabra*), *Eucalyptus* (*Eucalyptus obliqua*), *Neem* (*Azadirachta indica*), *Sheesham* (*Dalbergia sissoo*), Mango (*Mangifera indica*), Poplar (*Populus deltoides*), Teak (*Tectona grandis*), *Jamun* (*Syzygium cumini*), *Kanak Champa* (*Pterospermum acerifolium*), Drumstick (*Moringa oleifera*), *Jungle Jalebi* (*Pithecellobium dulce*) were dried and grinded. Wood powder along with agar was tried for making laboratory diet for rearing of termites. Among these, the diet prepared out of wood powder of *sheesham* (15 gm) with agar powder (5 gm) in 250 ml water was found better



A B C D

Fig. 9.1. A: Diagramatic representation of termite soldier B: *Odontotermes vaishno* Bose C: *Odontotermes bellahunisensis* Holmgren and Holmgren D: *Odontotermes horni* (Wasmann)

over others for rearing of termites. Termites (both workers and soldiers) could survive up to 52 days. In order to check growth of unwanted microorganisms, the diet was amended with cycloheximide and streptomycin sulphate.

Evaluation of different anti-protozoan medicines against termites

Different anti-protozoan chemicals *viz*., Metronidazole; Albendozole; Ornidazole; Tinidazole; Nitazoxanide were evaluated for their bio-efficacy against termites under laboratory condition using artificial diet. Amongst these, 100 per cent mortality of termites was recorded in 11 days in the treatment of Ornidazole and Tinidazole, while it was in 15, 18 and 23 days in case of Metronidazole, Nitazoxanide and Albendozole, respectively. Termites could survive up to 50 days in untreated control. The mortality amongst the termite population is attributed to the possible gut defaunation, which ultimately resulted into failure in digestion of cellulose by the termites.

Evaluation of different treatments against termites under field condition

Field evaluation of different entomo-pathogens and insecticides against termites was done under randomized block design with 10 treatments and three replications. Amongst entomopathogens, *Beauveria bassiana* @ 2.5 kg/ha ($1x10^8$ cfu/gm); *Metarhizium anisopliae* @ 2.5 kg/ha ($1x10^8$ cfu/gm); *Purpureocillium lilacinum* @ 2.5 kg/ha ($1x10^8$ cfu/gm) and *Bacillus subtilis* @ 3 litre/ha ($1x10^9$ cfu/ml), while amongst the insecticides, Chlorantraniliprole 18.5% SC @ 600 ml/ha; Imidacloprid 17.8% SC @ 350 ml/ha; Bifenthrin 10% EC @ 1.0 litre/ha and Chlorpyrifos 20% EC @ 6.25 litre/ha and one treatment of cultural practice of weekly irrigation for 4 weeks from planting onwards along with untreated control were evaluated against termites. Results have indicated that germination per cent at 30 days after planting (DAP) was more than 35 per cent in all the insecticide treatments, while it was only 13.32 per cent in weekly irrigation and 19.71 per cent in untreated control. Termite infestation was the lowest in insecticide treated plots at 60 and 90 DAP. The difference of termite infestation amongst the treatments of insecticides was non-significant. Similarly, difference of treatments amongst the entomopathogens was also non-significant. However, treatment of *P. lilacinum* was numerically best amongst these as only 4.68 per cent and 4.74 per cent of termite infestation was recorded on 60 and 90 DAP, respectively. Termite infestation was recorded to the tune of 8.95 and 11.69 per cent on 60 and 90 DAP, respectively in weekly irrigated plot while the worst affected plots were untreated control plots with a per cent infestation of 10.07 and 18.35 on 60 and 90 DAP, respectively. The highest NMC of 1,29,620 and yield of 85.18 t/ha was recorded in the treatment of Chlorantraniliprole 18.5% SC, while the lowest NMC of 73,690 and yield of 46.66 t/ha was recorded in the treatment of weekly irrigation for initial four weeks. Based on the data, it can be concluded that although insecticides are the most effective tools in managing termites in sugarcane, the entomopathogens were also found to be quite effective and surprisingly weekly irrigation failed to check the termite infestation.

CHAPTER 10

Outreach Programmes and Technology Management

Entrepreneurship development for sugarcane seed production and multiplication

Seed cane crop of varieties *viz.*, CoLk 94184, CoLk 09204, Co 98014, CoPk 05191, Co 0118, Co 08272, Co 08279 was planted on farmers' fields in Sitapur and Lakhimpur districts of Uttar Pradesh. A total of 35 seed cane plots in 20.00 ha area were maintained in fields of 30 farmers (Table 10.1).

Table 10.1. Number of plots and area under seed cane crop of each variety

Sr. No.	Name of variety	Area (ha)	No. of seed plots
1	CoLk 94184	5.00	10
2	Co 0118	6.00	11
3	CoLk 09204	2.00	4
4	Co 08272	2.00	4
5	Co 98014	2.00	4
6	CoPk 05191	1.50	1
7	Co 08279	1.50	1
Total		**20.00**	**35**
Total number of farmers		**30**	

The entrepreneurship trainings for beneficiary farmers were organised in the months of September, October and December to provide information in seed cane crop raising, motivate the farmers for enterprising in cane seed production and multiplication of new sugarcane varieties. The data on entrepreneurial ability of farmers (20) 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

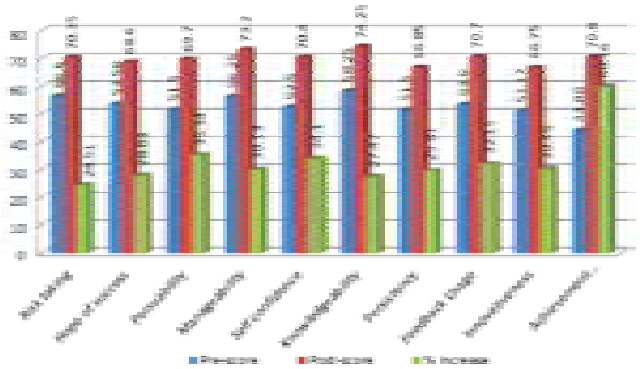


Fig. 10.1. Entrepreneurial behaviour index of farmers

Table 10.2. Entrepreneurial behaviour index of farmers (n=20)

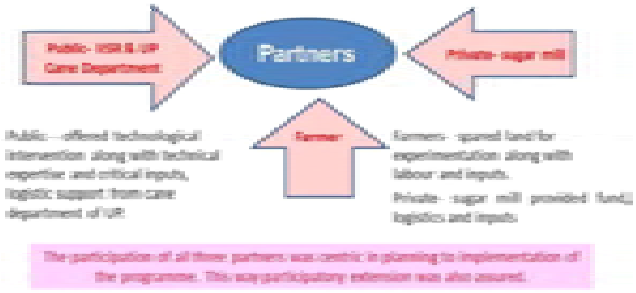
S. No.	Attributes	Entrepreneurial behaviour index (%)		% Increase	Rank
		Pre	Post		
1	Risk taking	56.50	70.35	24.51	X
2	Hope of success	53.58	68.60	28.03	VIII
3	Persuasibility	51.50	69.70	35.34	II
4	Manageability	56.25	73.20	30.13	VI
5	Self confidence	52.50	70.40	34.10	III
6	Knowledgeability	58.25	74.25	27.47	IX
7	Persistency	51.50	66.85	29.81	VII
8	Feedback usage	53.50	70.70	32.15	IV
9	Innovativeness	51.17	66.75	30.45	V
10	Achievement motivation	44.08	70.60	60.16	I
Entrepreneurial behaviour index		52.88	70.65	33.60	

entrepreneurial behaviour index (EBI) are presented in Table 10.2.

Table 10.2 reveals that overall EBI was increased by 33.60%, however, the maximum increase of 60.16% 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.

Model developed: Public-Private-Farmer Partnership (PPFP) model in sugarcane to double farmers' income

In the recent time, 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, a Public-Private-Farmer Partnership (PPFP) model was developed and implemented. 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 30,000 progressive farmers and development workers from



other States visited farmers' fields where interventions were introduced in PPFP mode and interacted with beneficiary farmers, this way farmer-to-farmer extension also happened there.

Technology assessed in farmers' fields

PGR in sugarcane

The assessment trial was conducted in the farmers' fields in the mill zone area of Biswan Sugar mill in the month of October, 2019 under autumn planting. Treatments include setts soaking in ethrel @ 100 ppm (25 ml/100 litres) for 24 hours before their planting; foliar spray of 200 ppm ethrel at 25 DAP and three cane varieties *viz*., CoLk 94184, Co 0238 and Co 0118.

Autumn planting with two bud setts

Growth/Economic parameters	Control	Treated	% increase
Germination (%)	42	58	38.10
Initial shoot population at 45 DAP/ ha	50,600	66,000	30.43

An analysis of gender perspective in sugarcane cultivation

Operational Difficulty Index has been developed to measure the operational difficulty of sugarcane production technologies. A composite data collection tools has been prepared, pre-tested among the non sample farmers and finalized after incorporating the required modification.

Information and technology utilization pattern of the sugarcane farmers

Review of literature has been completed and preparation of interview schedule is in progress.

Frontline demonstrations

For fast spread of newly released cane varieties, 30 FLDs on seed cane production technology was conducted in farmers' fields in Sitapur, Lakhimpur Kheri and Hardoi districts of Uttar Pradesh. Seed cane crop of varieties *viz*., CoLk 94184, CoPk 05191, Co 05011, Co 0118, CoLk 09204, Co 98014 and CoS 08272 was raised in demonstration fields with recommended package of practices.

Frontline demonstrations of IISR tractor operated disc type ratoon management device

The frontline demonstration of IISR ratoon management device was conducted in Hardoi, Sitapur and Lucknow districts. It took nearly three hours per hectare of ratoon field to complete all assigned task in one pass of the tractor. Each sub-units were adjustable and, if need be, could be detached from the equipment *eg*. it is advised to detach the stubble shaving unit from the main frame of the equipment while operating in fields where harvesting of the preceding crop was done in phases or in fields with healthy tillers. Realistically farmers in the selected village preferred to get RMD operated without shaving tillers. The crop was managed by the farmers.

Ratoon management device was operated in farmers' fields in accordance with the recommendations (Fig. 10.2). Operations like deep tilling, off barring, basal dose of fertilizers in free-flowing were got executed in the presence of farmers. Adjustments were made as per the requirement of the crop. It may be pointed out that planting of the preceding crop was done with the help of sugarcane cutter planter in straight lines at 75 cm inter row-spacing.

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

Off barring discs could, however, be adjusted to work 20-30 cm sideways from the centre of the stubble-row to prevent such damage. It is worth to mention that sugarcane grows with a dense cluster of roots spreading 30-40 cm sideways and 10-100 cm deep inside the soil. Well-established plant-stubbles provide desirable anchorage for sharp cutting of old roots with minimal damage.

Approximately 5.5 ha area was covered by IISR RMD in 15 farmers' fields. Feedback information from the farmers' field yielded the necessity of simplifying the metering and power transmission system of the equipment.

Frontline demonstrations of IISR tractor operated deep furrow sugarcane cutter planter

IISR tractor operated deep furrow sugarcane planter was demonstrated at farmers' field of Shahjahanpur, Lakhimpur Kheri and Kushinagar districts of Uttar Pradesh in 15 ha area. Planter under field operation is shown in Fig. 10.3. Total 16 farmers used the planter. The performance of the planter was satisfactory for planting of sugarcane (including sett cutting) at farmers' field. Cost of planting operation was ₹ 2,780 per ha using the planter as compared to ₹ 7,380 per ha in conventional method.

Fig. 10.3. IISR tractor operated deep furrow sugarcane planter in field operation at farmers' field

Frontline demonstrations of IISR tractor operated sugarcane trench planter

Trench planter was demonstrated at farmers' field in villages of Hardoi, Barabanki and Lucknow districts (Fig. 10.4). A total of 8 ha area was covered at farmers field covering 10 farmers. The equipment plants one pair of rows at a spacing of 30 cm in the single pass. Tractor rear wheel marking is utilized to maintain inter pair spacing of 120 cm. The effective field capacity of the equipment was 0.20 ha/h with a field efficiency of 65-70%. The performance of the planter was satisfactory in accomplishing the unit operations involved in cane planting such as furrow opening, sett cutting, placement of cut setts into the furrows, application of fertilizer and chemical insecticide, covering of setts with soil and pressing the covered soil; in a single pass of the equipment.

Fig. 10.4. IISR sugarcane trench planter in field operation at farmers' field

Frontline demonstrations of IISR tractor operated deep furrow sugarcane cutter planter–cum-multicrop raised bed seeder

IISR tractor operated raised bed seeder-cum-sugarcane planter was operated at farmers' field at Biswa sugar mill area of Sitapur district in 16.10 ha area covering 24 farmers (Fig. 10.5). 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 seed of companion crop of pulses were sown on the two raised beds. Performance of the planter was satisfactory with effective field capacity of 0.20 ha/h.

Fig. 10.5. IISR tractor operated deep furrow sugarcane cutter planter-cum-multicrop raised bed seeder in field operation at Manpur, Sitapur

Frontline demonstrations of IISR tractor operated sugarcane-cum-potato planter

IISR tractor operated sugarcane-cum-potato planter was operated at farmers' field at Harsiddhi village of Bihar and Lucknow in 4.5 ha area. The planter makes two furrows at a spacing of 75 cm and two ridges in between two successive furrows. Two furrows are planted with the cane and seed of potato is planted on ridges simultaneously in single pass of the planter.

On-station demonstration

To showcase the cane production technology to dignitaries and visitors, on-station demonstration in one ha area was laid out in Technology Park. Planting methods, intercropping with sugarcane, IPM, cane node technique, plant growth regulator and cane varieties were demonstrated.

Field day organized

Following field days were organized:

1. 19th April, 2019 at Dokti, Ballia, U.P.
2. 11th May, 2019, Paliya, Lakhimpur Kheri, U.P.
3. 18th August, 2019 at Biswan, Sitapur, U.P.
4. 25th October, 2019 at Haidergarh, U.P.
5. 30th December, 2019 at Manpur, Biswan, Sitapur, U.P.

Establishment of quality jaggery production-cum-training units in selected districts of Uttar Pradesh for income generation and entrepreneurship development (Externally funded project: RKVY, Govt. of U.P.)

- One IISR model Jaggery Unit has been established at KVK, Gorakhpur.
- A new DST funded (₹ 35 lakh) project under Women Scientist Scheme B (WOS B) entitled "Modified Atmosphere Packaging of Sugarcane Juice in Closed System" has been sanctioned.

Details of transfer of technology related to jaggery

Name of technology transferred / adopted	No of units	Address of farmers/ entrepreneurs/ manufacturers
IISR 3-pan jaggery unit	14	• Department of Agriculture, Mizoram -1 • DIC, Muzaffarnagar, U.P. -5 • Hoshangabad, M.P. -1 • Mirzapur, U.P. -2 • Lucknow, U.P. -1 • Sitapur, U.P. -2 • Hoshiarpur, Punjab -2
Moulding frame	100 sets	
Value added jaggery	04	• Mr. Ankit Sharma, Bhopal, M.P. • Mrs. Sandhya Rao, Deoria, U.P. • Mr. Rahul Balyan, Muzaffarnagar, U.P. • Mr. Nitin Gandhi, Ludhiana, Punjab

MoA's signed

Two MoA's were signed with entrepreneurs for establishing IISR model jaggery units as per following details:

- M/s Tuture Farmers LLP, 207-A Bhagwan Parisar, Hoshangabad Road, Misrod, Bhopal, M.P.
- Mrs. Sandhya Rao W/o Mr. Gorakhnath Rao, Village & Post- Bakhra, Distt. Deoria, U.P.

Linkages developed

Technical collaboration with ITC Limited was initiated and a collaborative programme proposal has been prepared for skill development of progressive farmers and NGO personnel in water saving cane technologies, SSI and seed cane business.

Entrepreneur farmer developed

Two farmers were developed as entrepreneurs and they are doing seed cane business. They were recognized by State Cane Department/All India Radio/*Doordarshan* by inviting them to share their experiences on success achieved.

Exhibitions organized

Programme	Place	Date(s)	Number of visitors
Krishi Samridhi Mela	Haidergarh, Barabanki, U.P.	October 25, 2019	1,000
Zone level three days Agro-climatic Mega Farmers Fair/Exhibition	Acharya Narendra Dev Inter College, Pathardeva, Deoria, U.P.	December 21-23, 2019	1,000

CHAPTER 11

Krishi Vigyan Kendra

I. KVK, Lucknow

On-farm testing/trials (OFTs): Four OFTs were conducted pertaining to various disciplines as per identified major thrust areas. OFTs are the most important mandatory component of KVK under which evaluation of recently developed technologies or varieties is done in specific agro climatic condition for future recommendations or popularization, which are given below:

Integrated nutrient management in potato

Problem diagnosed: Excess and imbalance use of plant nutrients without soil test

Technology assessed: Potato growers of Lucknow district are using excess fertilizers especially phosphatic fertilizer (DAP), due to which, crop needs more number of irrigation and become more prone to insects and diseases that increases cost of cultivation. So keeping this in view, an OFT was conducted on integrated nutrient management in potato at farmers' fields. The results are awaited.

Use of hand wheel hoe for weed management

Problem diagnosed: Farm women/farmers do weeding through hoe for reducing drudgery

Technology assessed: Farm women do many difficult tasks and weeding of the crops is one among them. It is a main drudgery prone activity which is mostly performed by farm women. So keeping this in view, an OFT has been conducted on evaluation of efficiency and reduction of drudgery of farm women in weed management using hand wheel hoe at farmers' field. The results are awaited.

Management of thrips in mango orchards

Problem diagnosed: Mango crop of Lucknow district suffering from infestation of sucking pests especially thrips that affect growing shoot leading to downfall of crop growth and yield.

Technology assessed: Lucknow district is famous for mango cultivation, For the last few years, there is heavy incidence of thrips. For its management, farmers use many types of insecticides in unjudicious manner. So keeping this in view, an OFT was conducted for its management in effective and economical manner. The results are awaited.

Integrated disease management in vegetable pea

P roblem diagnosed: Yield loss due to incidence of root rot, collar rot and powdery mildew in vegetable pea.

Technology assessed: Vegetable pea is an important vegetable crop of Lucknow district. Root rot and powdery mildew are important diseases which severely affect the crop. Generally, farmers do not use any control measures for its management. So keeping this in view, an OFT was conducted for the evaluvation of efficacy of different fungicides in vegetable pea for overcoming the problems. The result is awaited.

Frontline demonstrations (FLDs)

Total 1290 frontline demonstrations were conducted in 223.18 ha area. Demonstrations on oilseeds and pulses were covered on an area of 101 and 50 ha, respectively under National Food Security Mission (NFSM). FLDs were conducted in cereals and horticultural crops, covering the area of 25 and 12 ha, respectively, while 27.18 ha area was covered under fodder demonstration under National Initiative on Fodder Technology Demonstration (NIFTD). For farmwomen, large number of demonstrations were conducted on various aspects like nutritional kitchen gardening (79), basket making (10) and bag making (10) under Nutrisensitive Agricultural Resource and Innovation (NARI) Project. Animal health management through vaccination, deworming and UMMB of 1015 animals (buffaloes and cows) was also carried-out under FLDs.

Training programmes conducted: *Krishi Vigyan Kendra* offered 67 training courses for participating farmers and farm women on various topics with an objective to improve skill and upgrade their knowledge about developed and potent products. All training programmes were fully skill oriented and conducted following the principles of "Learning by doing". One thousand five hundred eighty seven participants (1274 males and 313 females) attended the programme.

Crop	Area (ha)	No. of demonstrat-ions	Average production (q/ha)		% increase in yield
Cereal crop			**Demo**	**FP**	
Rice (Pusa Basmati-1637)	5.0	23	41.5	36.7	11.56
Rice (Arize AZ 6633)	10.0	23	65.8	56.2	14.59
Rice (Management of Yellow Stem Borer)	10.0	20	65.4	56.2	14.97
Total	**25.0**	**66**			
Pulse crop					
Blackgram (KUG 479)	10.0	43	4.96	3.21	35.28
Greengram (Shikha)	10.0	45	5.34	3.60	32.58
Chickpea (Ujwala)	10.0	130	Result awaited		
Fieldpea (HFP 529)	20.0	242	Result awaited		
Total	**50.0**	**460**			
Oilseed crop					
Sesamum (RT 351)	10.0	47	3.18	2.46	22.64
Mustard (Giriraj)	81.0	253	Result awaited		
Toria (Uttara)	10.0	49	Result awaited		
Total	**101.0**	**349**			
Vegetable crop					
Cowpea (Kashi Nidhi)	1.0	15	150.5	127.9	17.7
Kharif Onion	1.0	13	330.5	261.5	26.5
Onion	1.0	11	Result awaited		
Vegetable Pea	5.0	42	Result awaited		
Potato	2.0	06	Result awaited		
Total	**10.0**	**87**			
Cash crop					
Mango (Management of Leaf Webber)	2.0	5	Result awaited		
Total	**2.0**	**5**			
Others					
Hybrid Sweet Sorghum (SSV 84)	10.00	67	597.6	526.1	11.9
Perennial fodder grasses (Napier/Dhwaloo)	1.00	08	Result awaited		
Barseem (Mescavi)	10.0	88	Result awaited		
Oat (Kent)	5.0	61	Result awaited		
Nutritional kitchen gardening	1.18	79	Result awaited		
Basket making	-	10	Result awaited		
Bag making	-	10	Result awaited		
Total	**27.18**	**323**			
Grand Total	**223.18**	**1290**			

ii) Livestock	No. of animals	No. of demonstrations
Buffalo (UMMB)	15	04
Cattle and Buffalo (Vaccination)	1000	275
Total	**1015**	**284**

Area of training	No. of courses	Farmers training		
		Male	**Female**	**Total**
Horticulture	10	199	1	200
Livestock production and management	15	317	-	317
Home science/women empowerment	15	26	249	275
Plant protection	10	224	17	241
Sponsored training programme	15	468	46	514
Total	**65**	**1234**	**313**	**1547**

Area of training	No. of courses	Duration (days)	Vocational training		
			Male	**Female**	**Total**
Button mushroom production	2	10	40	0	40
Total	**02**		**40**	**-**	**40**

Extension activities conducted

Activity	No. of programmes	No. of farmers	No. of extension personnel
Diagnostic visits	1	5	-
Group discussions	8	451	18
Kisan goshthi	4	690	47
Film show	3	180	-
Kisan mela	2	550	38
Exhibition	1	500	-
Scientists' visits to farmers field	127	1,441	4
Farmers' visits to KVK	9	734	17
Lecture delivered	85	4,597	65
Mobile advisory	9	603	-
Radio talk	5	-	-
T.V. talk	4	-	-
Method of demonstrations	1	40	2
Celebration of important days	5	714	22
Special day celebration	3	230	10
Others			
Live telecast programme	4	710	17
Plantation of tree	1	550	8
Visit of RAWE students	02	22	1
Kisan Pathshala	02	68	20
Total	**276**	**12,085**	**269**

SMS sent to farmers

SMS sent to farmers through portal	No. of SMS	No. of farmers
	20	1,91,785

Other programmes organized

- Organized live telecast of "*Vaigyanikon Ki Baat Kisano Ke Sath*" programme on June 6, 2019 at KVK, ICAR-Indian Institute of Sugarcane Research, Lucknow.
- Organized plantation day programme on July 6, 2019 at KVK, ICAR-Indian Institute of Sugarcane Research, Lucknow.
- Organized an awareness campaign on 'Water conservation and water management' under *Jal Shakti Abhiyan* in collaboration with ICAR-CSSRI Regional Centre, Lucknow at Village, Karasanda, Gosaiganj, Lucknow on August 9, 2019.
- Organized *Parthenium* eradication awareness programme on August 22, 2019 at KVK, ICAR-Indian Institute of Sugarcane Research, Lucknow.
- Organized Farm Machinary Enterpenurship Seminar and Expo-2019 on October 24, 2019 at ICAR-Indian Institute of Sugarcane Research, Lucknow.
- Organized live telecast of Launching of NADCP for FMD & Brucellosis and National Artificial Insemination and *Swachhata Hi Seva* Programme on November 9, 2019 at ICAR-Indian Institute of Sugarcane Research, Lucknow.
- Organized "*Vrihad Vriksharopad Karykram*" at Village-Karasanda, Gosaiganj, Lucknow on September 17, 2019.
- Organized a live telecast of Awareness Programme on Balanced Use of Fertilizer Application and Importance of Soil Health Cards on October 22, 2019 at KVK, ICAR-Indian Institute of Sugarcane Research, Lucknow.
- Organized "Flag Off Publicity Van - Awareness Campaign" in collaboration with Petroleum Conservation Research Association (PCRA), New Delhi on November 7, 2019 at KVK, ICAR-Indian Institute of Sugarcane Research, Lucknow.
- Organized World Soil Health Day on December 5, 2019 at Village-Hardaspur, Lucknow.
- Organized *Kisan Diwas* in honour of Birth Anniversary of 5th Hon'ble Prime Minister of India, Shri Choudhary Charan Singh at Village-Amirpur, Block-Gosaiganj, Lucknow on December 23, 2019.

Seed and planting material production

i) Seed production

Crop	Quantity (q)
Cereal	
Wheat	45
Total	**45**
Pulses	
Chickpea	15.12
Pigeonpea	0.50
Total	**15.62**
Elephant Foot Yam	5.00
Colocasia	10.0
Turmeric	2.00
Total	**17.0**
Grand Total	**77.62**

ii) Planting material production

Crop	No. of planting materials
A. Fruit saplings	
Lemon	500
Moringa	1,000
Mango root stock	2,500
Sub-total (A)	**4,000**
B. Vegetable seedlings	13,000
Sub-total (B)	**13,000**
Grand Total (A+B)	**17,000**

iii) Production of bio-products

Bio-products	Quantity (kg)
Vermi compost	995

iv) Others

Produce	Quantity (kg)
Mango pickle	80

Soil testing

Samples	No. of samples tested
Soil	378


कृषि विज्ञान केन्द्र


किसान दिवस

II. KVK, Lakhimpur Kheri

Activities undertaken by KVK, Lakhimpur Kheri were as follows:

Activity	No
Frontline demonstration	1
On-farm trial	1
Diagnostic visits	4
Advisory services	580
Celebration of important days	8
Exhibition	1
Farmer-scientist interaction	1
Farmers visit to KVK	1
Group meeting/Discussion	3
Field day	4
Film show	2
Kisan Goshthi	4
Method demonstrations	1
Scientist visit to farmer field	3
Soil health camp	1
Newspaper coverage	6
Total	**62**

Training programmes organized

Discipline	Farmers		Rural Youth	
	No. of training	No. of trainees	No. of training	No. of trainees
Animal Science	4	80	1	40
Agronomy	2	50	1	30
Total	6	130	2	70

FLDs

Four frontline demonstrations on sugarcane on variety CoLk 11906 were conducted at four farmers fields.

On farm multilocation yield trial on groundnut during *Kharif* 2019

A multi-location yield trial consisting Demonstrations on Groundnut Var. Girnar-2 at ten different locations of the Community Development Block was conducted.

Block name	Yield obtained in demonstration	Yield of check variety
Behjam 1	3.90	3.60
Behjam 2	3.66	3.24
Nakha 1	4.44	4.02
Nakha 2	4.08	3.60
Lakhimpur 1	3.12	2.80
Lakhimpur 2	3.63	3.36
Phool Behar 1	4.38	3.99
Phool Behar 2	4.02	3.69
Dhaurahara 1	3.72	3.36
Dhaurahara 2	3.99	3.60

Other activities include production of wheat seed variety HD-2967 (50 q), distribution of six poultry birds and 105 fruit saplings to the farmers.

Various programmes organized

Massive tree plantation campaign

A large plantation campaign and farmers' seminar was organized by ICAR-KVK, Manjhara, Lakhimpur Kheri on September 17, 2019, in the auditorium of Deputy Director Agriculture Extension. Mr. Ajay Mishra 'Teni, Hon'ble Member of Parliament highlighted the importance of plantation for the environment. He urged every person to plant at least five trees. Around three hundred farmers participated in this programme. A total of 1400 saplings including fruit saplings of Mango, Pomegranate, Lemon, Guava and Chhatwar were distributed to the farmers by the Hon'ble Member of Parliament.

Awareness programme on balanced use of fertilizer application

KVK, ICAR-IISR, Lakhimpur Kheri organized a live telecast of awareness programme on balance use of fertilizer application and importance of soil health card. The programme was inaugurated by the Chief Guest, Dr. R.N. Mall, Deputy Director (Silkworm), Lakhimpur Kheri. He emphasized on precise use of fertilizer. Head, KVK, Dr. Niranjan Lal motivated the farmers for fertigation specially in vegetable crops. He also welcomed all the dignitaries and participants. During this programme, 203 participants actively participated.

World Soil Day

KVK, ICAR-IISR, Lakhimpur Kheri organized a World Soil Health Day on 5th December, 2019 at village Fardhan, Lakhimpur Kheri. Dr. Baburam, DDO, Lakhimpur Kheri called upon farmers not to use more and more fertilizer and told about the importance of soil health for the effective crops. On this occasion, Dr. Niranjan Lal, Head, KVK highlighted the importance of soil testing. He urged the farmers to use the balanced dose of fertilizer on the basis of results of soil testing. On this occasion, soil samples were collected from Pratappur village of Lakhimpur Kheri. One thousand eight farmers participated in this programme.

Goat farming-a profitable business

KVK, ICAR-IISR, Lakhimpur Kheri organized a Goat Farming Profitable Business on December 21, 2019 at village Bela Pursua, Lakhimpur Kheri. The Animal Husbandry Specialist of this programme, Dr. Devendra, DFS, Lakhimpur Kheri highlighted the importance of goat farming and urged farmers to adopt more and more goat farming. The programme was attended by 108 farmers.

Celebration of *Kisan Diwas*

KVK, ICAR-IISR, Lakhimpur Kheri organized *Kisan Diwas* to celebrate the birth anniversary of the fifth Prime Minister of India, Chaudhary Charan Singh at Block Phoolbehar, Lakhimpur Kheri on December 23, 2019. The Chief Guest of this programme, Smt. Preeti Tiwari, Block Development Officer, Lakhimpur-Kheri acquainted the farmers about the contribution of Ex. Prime Minister of India. Dr. Niranjan Lal, Sr. Scientist & Head delivered a lecture on organic farming. Total 150 farmers from different villages actively participated in the programme.

Van Mahostav

One week *Van Mahostav* programme was organised by KVK, Lakhimpur from July 1-7, 2019. During the programme, 100 sampling were planted and 25 school students participated in the programme.

CHAPTER 12

Services to the Industry

Contract Research

ICAR-IISR, Lucknow carried out the evaluation for some new industrial products which have the use in sugarcane cultivation. The evaluation of products such as insecticides, pesticides, weedicides, fungicides and other chemical formulations has been carried out on sugarcane crop. The evaluation was carried out signing a Memorandum of Understanding with the manufacturers as per the details given in Table 12.1.

Table 12.1 Memorandum of Understanding for Contract Research

Contracting party	Contract Research
Sumitomo Chemical (India)	Bio-efficacy and phyto-toxicity evaluation of 'Flumioxazin 50% SC' against weeds in sugarcane and its effect on succeeding crop (V.P. Singh, K.K. Singh, V.P. Jaiswal and S.K. Shukla, 10/16-08/19, Budget ₹ 10.0 lakh)
ISK Biosciences India Pvt. Ltd.	Bioefficacy evaluation of SL 160 10% herbicide against weed control of sugarcane (V.P. Singh, A.P. Dwivedi, V.K. Singh and K.K. Singh; 03/17-12/19, Budget ₹ 10.0 lakh)
ADAMA India Private Limited	Bioefficacy evaluation of Ametryn 80% WDG herbicide against weed complex of sugarcane (V.P. Singh, V.K. Singh, K.K. Singh and A.P. Dwivedi; 03/17-12/19, Budget ₹ 10.0 lakh)
Meghmani Organics Ltd., Ahmedabad	Bio-efficacy evaluation of Atrazine 50% WDG herbicide against weed complex of sugarcane (K.K. Singh, V.P. Singh, S.K. Shukla and V.P. Jaiswal; 03/17-09/19, Budget ₹ 10.0 lakh)
PI Industries Limited	Evaluation of PII 8007 20% SC against termites and cane borers of sugarcane and its effect on bio-agents and crop (M.R. Singh and A. Baitha; 5/17-09/19; Budget ₹ 7.5 lakh)
BASF India Ltd., Navi Mumbai	Evaluation of bio efficacy and phyto-toxicity of pre-emergent application of Saflufenacil 68 g/l + Dimethoanamid-P 600 g/1 EC (Integrity 668 g/1 EC) against weeds in sugarcane and its effects on succeeding crop (S.K. Holkar, D.N. Borase and Y.E. Thorat, 05/18-05/20; Budget ₹ 15.0 lakh)
FMC India Pvt. Ltd.	Evaluation of Chlorantraniliprole 18.5% SC and 0.4% GR against insect pests of sugarcane (S.N. Sushil, Arun Baitha and A.K. Jaiswal; 05/18 – 05/19, Budget ₹ 10.0 lakh)
Sirius Minerals India Pvt. Ltd., New Delhi	Efficacy of POLY 4 on growth behaviour, yield attributes, yield and soil health of sugarcane (M.K. Tripathi, S.N. Singh, V.P. Singh, S.K. Shukla and A.P. Dwivedi, 10/18-02/21, Budget- ₹ 25.64 lakh)
Bayer Crop Science Ltd., Mumbai	Bio-efficacy of Vayego Superb (Tetraniliprole 0.4% + Fipronil 0.6% Gr against early shoot borer, top shoot borer and white grub in sugarcane (M.R. Singh and Arun Baitha; 05/18-05/20; Budget ₹ 10.0 lakh)
United Phosphorus Ltd., Mumbai	Bio-efficacy & phyto-toxicity evaluation of UPH 114b against weeds in sugarcane (V.P. Jaiswal, V.P. Singh, Lalan Sharma, S.K. Shukla and Anita Sawnani; 02/19–08/21; Budget ₹ 15.0 lakh)
United Phosphorus Ltd., Mumbai	Bio-efficacy and phytotoxicity of fungicide "SAAF Gr (Carbendaim 1.92 + Mancozeb 10.08% GR) against the Pokkah Boeng disease of sugarcane (Lalan Sharma, V.P. Jaiswal, S.K. Shukla and A.D. Pathak; 02/19-03/21, Budget ₹ 12.0 lakh)
United Phosphorus Ltd., Mumbai	Irrigation water saving in sugarcane through application of superabsorbent (Zeba) under field condition (A.P. Dwivedi and A.D. Pathak; 11/19-12/21; Budget ₹ 10.0 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, S.R. Singh, M.K. Tripathi and R.K. Singh; 03/17-07/19, Budget ₹ 10.0 lakh)
Agrinos India Private Limited	Assessing efficacy of Agrinos VAM (Arbuscular Mycorrhizal Fungi) on the productivity of sugarcane and sugar in sub-tropical India (S.N. Singh, A.D. Pathak, V.K. Singh, S.R. Singh and R.K. Singh; 05/19-04/21, Budget ₹ 10.0 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 and M.K. Tripathi; 09/19-12/22, Budget ₹ 15.0 lakh)

CHAPTER 13

Human Resource Development

ICAR sponsored 10-days Short Course organized

ICAR sponsored 10-days Short Course on "Advances in sugarcane mechanization technologies to reduce cost of operations and drudgery for enhancing farmers' income" was organized at ICAR-Indian Institute of Sugarcane Research, Lucknow from September 16-25, 2019. Dr. Sukhbir Singh, Senior Scientist (FMP) was Course Director.

Twenty-five candidates participated in the Short Course. However, one candidate dropped out after two days. The candidates were mostly from State/Central Agricultural Universities and Research Institutes working on sugarcane. Out of total 24, 14 were male and 10 were women candidates representing eight States of the country *viz*., Bihar, West Bengal, Andhra Pradesh, Madhya Pradesh, Haryana, Uttarakhand, J&K and Uttar Pradesh. The participants had a range of backgrounds like Agricultural Engineering, Agronomy, Soil Science, Plant Breeding, Home Science/Agricultural Extension *etc.* The Short Course was inaugurated by Dr. S. Solomon, Hon'ble Vice-Chancellor, CSAUA&T, Kanpur & Former Director, ICAR-IISR, Lucknow. The compendium of the lectures in the form of a Training Manual was released on this occasion.

In 10 days, a total of 23 lectures including practical sessions were held. The lectures were mainly related to sugarcane mechanization *viz*., equipment for seed bed preparation, planting machines, intercropping machines, interculturing machines, harvesting and detrashing machines, ratoon management machines and improved manual tools. In practical, operation and maintenance of each machine were also covered. The generalized lectures on agronomy of sugarcane, insects & pests, MHAT, improved sugarcane varieties suited to mechanization, custom hiring, entrepreneurship development *etc.*, were also delivered by the experts. The lectures and practical on jaggery manufacturing and value addition were also covered. The fruitful deliberations in the Short Course instilled new ideas about the development/modification of new machines for sugarcane mechanization. The participants also visited the Institutes like CSIR-CIMAP, Lucknow; ICAR-NBFGR, Lucknow and had a look of ongoing research activities in those Institutes.

The Short Course ended on September 25, 2019. Dr. Kuldeep K. Lal, Director, ICAR-National Bureau of Fish Genetic Resources, Lucknow graced the Valedictory Session. The participants shared their views, discussed novel ideas and gave their feedbacks. They were extremely satisfied with the stay arrangement, food and the content of the Short Course. They also expressed their thankfulness and satisfaction on gain of knowledge regarding new tools/technologies learnt during this Short Course.

Human resource development of IISR researchers and staff

Name & Designation	Training Programme	Venue	Date
Dr. S.S. Hasan	Training Programme on "TOT and Embedded System Design"	NIELIT, Ludhiana	June 17 - July 16, 2019
Dr. Sangeeta Srivastava	National Workshop on Bioinformatics in Agriculture	ICAR-NAARM, Hyderabad	July 26-27, 2019
Dr. Niranjan Lal	Model Training Course on Soil Nutrient Management	ICAR Research Complex for NEH Region, Manipur, Imphal	September 1-11, 2019
Dr. Amaresh Chandra	Training on Recent Bioinformatics Tools for Genome and Proteome Analysis	ICAR-NAARM, Hyderabad	September 17-21, 2019
Dr. Sanjeev Kumar (Biotechnology)	Training Workshop for Institute Biosafety Officers and Scientists	ICAR-NIPB, New Delhi	September 20, 2019
Drs. Radha Jain, Sangeeta Srivastava, P.K. Singh and L.S. Gangwar	Implementation of E-Office	ICAR-IISR, Lucknow	October 22-23, 2019
Dr. Dileep Kumar	Short Course on "Advances in Sugarcane Mechanization Technologies to Reduce Cost of Operations and Drudgery for Enhancing Farmers' Income	ICAR-IISR, Lucknow	September 16-25, 2019
Dr. Rajesh Kumar	Training Workshop for Vigilance Officers of ICAR	ICAR-NAARM, Hyderabad	October 31 - November 01, 2019
Dr. L.S. Gangwar	DST sponsored Training Programme on Science Administration and Research Management	ASCI, Hyderabad	November 4-15, 2019
Dr. Amaresh Chandra	National Workshop on Gene Editing for Enhancing Plant Productivity and Stress Tolerance	ICAR-IIRR, Hyderabad	November 10 - 12, 2019
Technical Staff			
Shri R.K. Singh	Seminar on Priorities and Strategies to Boost Farmers' Income	ICAR-IISR, Lucknow	June 14. 2019
Dr. Om Prakash	Training on Doubling Farmers Income in Sugarcane Sector	ICAR-IISR, Lucknow	July 16-20, 2019
Shri Sant Ram	Training Programme on Capacity Building and Skill Upgradation Programme for Technical Staff for Farm Management	ICAR-IIFSR, Meerut	September 17-23, 2019
Dr. Anita Sawnani	Short Course entitled 'Integrated Approaches towards Addressing Hidden Hunger Challenge	MPUA&T University, Udaipur	September 16-25, 2019
Shri Ashish Singh Yadav	Training-cum-Workshop on J Gate @ CeRA for Northern Region	NASC Complex, New Delhi	October 23, 2019
Shri C.P. Prajapati	Capacity Building Programme towards a Secure & Resilient Workplace in ICAR	ICAR-CPRI, Shimla	November 25-27, 2019
Administrative Staff			
Shri Ganesh Prasad and Smt. Rashmi Sanjay Srivastava	Enhancing efficiency and behavioural skills of Stenographers Grade-III/PA/PS/PPS and Sr. PPS of ICAR Institutes	ICAR-CPRI, Shimla conducted by ICAR-NAARM, Hyderabad	June 20-25, 2019

Skill development residential trainings organized

Topic	Sponsoring Agency	Duration	No. of participants
Advances in Sugarcane Research and Development	IAS, BHU, Varanasi	May 08-15, 2019	22 students
Advances in Sugarcane Research and Development	IAS, BHU, Varanasi	June 17-22, 2019	15 students
Doubling Farmers' Income in Sugarcane Sector	MANAGE, Hyderabad	July 16-20, 2019	25 officers
Rural Agricultural Work Experience (RAWE) for B.Sc. (Ag.) Students	Pacific College of Agriculture, Udaipur	July 23- September 03, 2019	15 students
Advances in Sugarcane Research and Development	Quantum University, Roorkee	August 03-09, 2019	15 students

One day training-cum-visit organised

During the period, 41 one day training and visit programmes were organized at the Institute in which 679 farmers, 77 development personnel/scientists/ teachers and 571 students acquired latest know-how in scientific cane cultivation practices.

Date	Sponsored by	No. of trainees
21.04.2019	Farmers of Mizoram State	20 Farmers + 3 Officers
26.04.2019	ICAR-CISH, Rahmankheda, Lucknow, U.P.	12 Students + 2 Scientists
30.04.2019	RMD College of Agriculture & Research Centre, Ambikanagar (IGKV, Raipur), C.G.	58 Students + 4 Teachers
18.05.2019	CRPF Saristabad, Patna, Bihar	2 Farmers + 1 Student + 1 Teacher
29.05.2019	Department of Agriculture, Jabalpur, M.P.	22 Farmers + 2 Officers
17.06.2019	CBG Ag PG College, BKT, Lucknow, U.P.	25 Students + 3 Teachers
24.06.2019	Farmers of Faizabad, Aligarh and Sitapur districts of U.P.	5 Farmers
05.07.2019	Farmers of Lakhimpur Kheri, U.P.	2 Farmers
09.07.2019	Agriculture Technology FPO, Jahanabad, Bihar	1 Student
23.07.2019	Office of Deputy Coordinator Agriculture, Datia, M.P.	53 Farmers + 1 Official
26.07.2019	Department of Horticulture, Himachal Pradesh	2 Scientists
03.08.2019	Department of Agriculture, Office of the SDAO, Sihora, Jabalpur, M.P.	21 Farmers + 1 Officer
05.08.2019	Department of Agriculture, Damoh, M.P.	21 Farmers + 1 Officer
06.08.2019	DDA, Jabalpur, M.P.	27 Farmers + 2 Officers
08.08.2019	DDA, Vidisha, M.P.	17 Farmers + 1 Officer
06.09.2019	Office of the Senior Agriculture Development Officer, Narsinghpur, M.P.	20 Farmers + 2 Officers
09.09.2019	Office of Deputy Agriculture Coordinator, Guna, M.P.	24 Farmers + 1 Officer
11.09.2019	Office of Deputy Agriculture Coordinator, Satna, M.P.	33 Farmers + 2 Officers
13.09.2019	Farmers of Muzaffarnagar and Lucknow districts, U.P.	10 Farmers
13.09.2019	District Agriculture Officer, Lucknow	30 Input Dealers + 4 Officers
18.09.2019	Farmers of Kasganj, U.P.	5 Farmers
20.09.2019	ATMA, Agriculture Department, Sonbhadra, U.P.	39 Farmers + 2 Officers
24.09.2019	*Ganna Kisan Sansthan*, Muzaffarnagar, U.P.	45 Farmers + 2 Officers
26.09.2019	Deputy Director Agriculture, Hardoi, U.P.	50 Farmers + 1 Officer
15.10.2019	M.P. Council of Science & Technology, Bhopal, M.P.	112 Students + 10 Teachers
16.10.2019	Bhartiyan University, Coimbatore, T.N.	45 Students + 04 Teachers
16.10.2019	*Ganna Kisan Sansthan Evam Prashikshan Kendra*, Shahjahanpur, U.P.	41 Farmers + 1 Officer
16.10.2019	ATMA, Anooppur, M.P.	48 Farmers + 1 Officer
22.10.2019	ATMA, Rewa, M.P.	5 Farmers + 1 Officer
22.10.2019	ICAR-CISH, Lucknow Trainees	21 Scientists + 1 Officer
01.11.2019	*Ganna Kisan Sansthan*, Gorakhpur, U.P.	31 Farmers + 1 Officer
15.11.2019	SRM University, Lucknow, U.P.	105 Students + 05 Teachers
20.11.2019	Deputy Coordinator Agriculture, Datia, M.P.	31 Farmers + 1 Officer
21.11.2019	P.D. ATMA Office, Sheopur, M.P.	18 Farmers + 1 Officer
25.11.2019	SHUATS, Naini, Prayagraj, U.P.	71 Students + 03 Teachers
27.11.2019	Agriculture Department, Datia, M.P.	24 Farmers + 1 Officer
03.12.2019	P.D. ATMA, Umaria, M.P.	15 Farmers + 1 Officer
05.12.2019	Sacred Heart School, Lucknow, U.P.	84 Students + 4 Teachers
07.12.2019	SASRD, Nagaland	57 Students + 3 Teachers
17.12.2019	Agriculture Department, Jabalpur, M.P.	15 Farmers + 1 Officer
19.12.2019	P.D. ATMA, Satna, M.P.	35 Farmers + 1 Officer

Entrepreneurship training for promoting agri-business

The entrepreneurship in agriculture has been identified as 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. For these, several residential and off campus training programmes were conducted in which more than 200 participants were groomed as entrepreneurs to pursue agri-business in their available farming systems.

Training and capacity building organized

- One to two years ITI apprenticeship training organized in the Division of Agricultural Engineering for trainees in different trades namely fitter, welder, electrician, refrigeration & air conditioning *etc.*
- One-month Summer Training was conducted in the Division of Agricultural Engineering for students of B. Tech. (Ag. Engineering) of SHUATS, Prayagraj and MCAET, Ambedkarnagar during June-July, 2019.

Students visit under Inter-institutional HRD activities

Under inter-institutional HRD activity, conducted visits of students and teachers from SHUATS, Prayagraj; BHU, Varanasi; AMITY University, Lucknow; GD Goenka School, Lucknow; NDUA&T, Ayodhya; CSAUA&T, Kanpur and other institutions visited the Institute. Besides, about 500 UG/PG students visited IISR. During visit, they were imparted information on IISR research infrastructure, achievements and technologies developed through orientation lecture and visit to labs and fields.

CHAPTER 14

Awards and Recognitions

ICAR Awards

- ICAR-IISR, Lucknow received Rajarshi Tandon *Rajbhasha Puraskar* 2017-18 (First Prize) for big ICAR Institutes from ICAR on July 16, 2019 in New Delhi for the outstanding contribution in *Rajbhasha*. The award was received by Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow and Shri Abhishek Kumar Singh, Hindi Officer from Dr. Trilochan Mohapatra, Hon'ble Secretary, DARE and Director General, ICAR in the 91st Foundation Day and Award Ceremony of ICAR held at NASC Complex, New Delhi in the presence of Dr. Panjab Singh, Chancellor, Rani Laxmi Bai Central Agricultural University, Jhansi and Dr. A.K. Singh, DDG (Agril. Extension), ICAR.

Fellowships

- Dr. Rajesh Kumar was awarded UPAAS Fellowship–2017 for his outstanding contribution in the field of Social Sciences by Uttar Pradesh Academy of Agricultural Sciences on the 30th Foundation Day Celebration of Uttar Pradesh Council of Agricultural Research, Lucknow on June 14, 2019 at ICAR-Indian Institute of Sugarcane Research, Lucknow.

- Dr. Sanjeev Kumar, Principal Scientist (Agri. Biotechnology) was conferred the "Fellowship" in Crop Science by U.P. Academy of Agriculture Sciences (UPAAS) on the 30th Foundation Day Celebration of Uttar Pradesh Council of Agricultural Research, Lucknow on June 14, 2019 at ICAR-Indian Institute of Sugarcane Research, Lucknow.

- Dr. A.P. Dwivedi, Principal Scientist received the Fellow Award for outstanding performance and lasting contribution in the field of Agronomy on the occasion of International Conference on Advances in Agriculture under Changing Climate Scenario for Sustainable Global Development (AAUCSGD-2019) on November 16-17, 2019 at University of Allahabad, Prayagraj.

Professional Society Awards/Recognitions

- Dr. Amaresh Chandra received Prof. R. Kumar Distinguished Agricultural Scientist Award from UP Academy of Agricultural Sciences (UPAAS), UP Council of Agricultural Research (UPCAR), Lucknow on the 30th Foundation Day Celebration

of Uttar Pradesh Council of Agricultural Research, Lucknow on June 14, 2019 at ICAR-Indian Institute of Sugarcane Research, Lucknow.

- Dr. Sangeeta Srivastava was conferred "Outstanding Scientist Award 2019" in the 10th International Conference on Agriculture, Horticulture and Food Sciences ICAHFS-2019" held at New Delhi on December 21-22, 2019.

- Dr. Y.E. Thorat received the prestigious Prof. D. J. Raski Academic Merit Gold Medal Award-2019 of the Nematological Society of India (NSI) for an Outstanding Doctoral Thesis Research in the Science of Nematology by Dr. H. S. Gaur, Former Vice-Chancellor, SVPUA&T Meerut, on the occasion of the Golden Jubilee Year of NSI at National Symposium held at Manipur University, Imphal, India during December 11-13, 2019.

- Dr. A.K. Sah was elected Vice-President (Central Zone) of Indian Society of Extension Education, New Delhi for the year 2019-2022.
- Dr. Viveka Nand Singh, SMS, Horticulture received Excellence in Extension Award in 3rd National Conference on Promoting and Reinvigorating Agri-Horti, Technological Innovation (PRAGATI-2019) on December 24-25, 2019 by Green Agri Professional Society, Dhanbad.
- KVK adopted farmer, Mr. Mukesh Kumar awarded for button mushroom production in Lucknow district by Hon'ble Minister of Agriculture, Govt. of Uttar Pradesh on the occasion of *Kisan Samman Diwas* at *Vidhan Sabha*, Uttar Pradesh on December 23, 2019.

Paper presentation Awards

- Dr. Rajesh Kumar received the Best Paper Award in Technical Session-VI : Sugar Industry and Diversification Strategies of Fourth Annual Convention & Sugar Expo-2019 of North Indian Sugarcane and Sugar Technologists' Association (NISSTA) held on May 29-30, 2019 at National Sugar Institute, Kanpur.
- Dr. R.K. Singh, SMS (Animal Science) received the Best Oral Presentation Award on the research paper "Potentiality of Sweet Sorghum [(*Sorghum bicolour* (L.)] for Jaggery Production, by Singh, R.K., Dubey, A.K., Singh, V.N., Singh, Veenika and Rai, Deepak in International Conference on "Sustainable Agriculture Development in Changing Global Scenario" held on October 11-13, 2019 at Banaras Hindu University, Varanasi.
- Dr. Veenika Singh, SMS, Home Science received the Best Poster Presentation Award in Progressive Horticulture Conclave-2019 on Futuristic Technologies in Horticulture organized by Society of Horticultural Research and Development, Uttarakhand and ICAR-Central Institute of Subtropical Horticulture, Lucknow on December 10, 2019 at ICAR-Indian Institute of Sugarcane Research, Lucknow.

Other Recognitions

- Dr. S.N. Sushil acted as Member, Quinquennial Review Team of ICAR-National Centre on Integrated Pest Management, New Delhi.
- Dr. S.N. Sushil acted as Member, Research Advisory Committee of Uttar Pradesh Council of Sugarcane Research, Shahjahanpur.

- Dr. Amaresh Chandra was nominated as Member of Institute Management Committee of ICAR-SBI, Coimbatore; ICAR-CISH, Lucknow and ICAR-NIPB, New Delhi.
- Dr. Sangeeta Srivastava was nominated as Member, Institute Management Committee of ICAR-IISR, Lucknow for three years (2019-2022).
- Dr. Sanjeev Kumar, Principal Scientist (Agri. Biotechnology) was nominated by DG, ICAR, New Delhi as Member, Institute Management Committee of ICAR-IGFRI, Jhansi for three years (2019-2022).
- Dr. Sanjeev Kumar, Principal Scientist (Agri. Biotechnology) served as DBT Nominee for Institute Biosafety Committee of ICAR-IIPR, Kanpur.
- Dr. Amaresh Chandra acted as Co-Chairman of a Technical Session in National Workshop-2019 "Sugarcane: Challenges and Future Strategies for Doubling Farmers Income" held at ICAR-IISR, Lucknow on November 14, 2019.
- Dr. V.P. Singh chaired a session on "Presentation of salient findings by PI of Volunteer Centres and ICAR Institutes in Annual Review Meeting of AICRP on Weed Management held on October 16, 2019 at AAU, Jorhat, Assam.
- Dr. Rajesh Kumar was Chairman of Plenary Session II of Seminar on Sustainable Cane Development and Marketing in Subtropical India organized by North Indian Sugarcane held on October 11, 2019 at Avadh Sugar and Energy Ltd. Hargaon, Sitapur and Session of International Conference on Advances in Agriculture under Changing Climate Scenario for Sustainable Global Development (AAUCSGD-2019) on November, 2019 at University of Allahabad, Prayagraj.
- Dr. Rajesh Kumar was Co-Chairman of Technical Session-VI : Sugar Industry and Diversification Strategies of Fourth Annual Convention & Sugar Expo-2019 of North Indian Sugarcane and Sugar Technologists' Association (NISSTA) held on May 29-30, 2019 at National Sugar Institute, Kanpur.
- Dr. Rajesh Kumar was Co-Chairman in Sugarcane Agriculture Session - Session II in 77th Annual Convention & International Sugar Expo 2019 of The Sugar Technologists' Association of India held on July 17-19, 2019 at Biswa Bangla Convention Centre, Kolkata.
- Dr. Rajesh Kumar was Co-Chairman of Organizing Committee of Fourth Annual Convention & Sugar Expo-2019 of North Indian Sugarcane and Sugar Technologists' Association (NISSTA) held on May 29-30, 2019 at National Sugar Institute, Kanpur, India.
- Dr. Rajesh Kumar was nominated as Chairman to conduct computer skill test of Narendra Dev University of Agriculture and Technology, Ayodhya for recruitment of Programme Assistant, Stenographer and Assistants during June 27-29, 2019 at ICAR-IISR online examination centre.
- Dr. Rajesh Kumar was Organizing Secretary of Seminar on Sustainable Cane Development and Marketing in Subtropical India organized by North Indian Sugarcane and Sugar Technologists' Association (NISSTA) on October 11, 2019 at Avadh Sugar and Energy Ltd. Hargaon, Sitapur.
- Dr. Rajesh Kumar rendered his services as Rapporteur and preparation of proceedings of Plenary Session of Annual Group Meeting of All India Coordinated Research Project on Sugarcane held on October 14-16, 2019 at the University of Agricultural Sciences, Krishinagar, Dharwad (Karnataka).
- Dr. Sangeeta Srivastava Co-Chaired the Technical Session-IV of 10th International Conference on Agriculture, Horticulture and Food Sciences (ICAHFS-2019), held at New Delhi on December 21-22, 2019.
- Dr. A.K. Sharma was the Co-Chairman of the Plenary Session during NISSTA Seminar on Sustainable Cane Development and Marketing in Sub-tropical India held at Avadh Sugar & Energy Ltd., Hargaon, Sitapur (UP) on October 11, 2019.
- Dr. A.K. Sharma was the Co-Chairman of Technical Session-III during 3rd National Conference of Society for Veterinary & Animal Husbandry Extension (SVAHE) on Livestock Development for Societal Needs: Extension and Allied Sector Initiatives held at the Department of Veterinary & AH Extension Education, College of Veterinary and Animal Sciences, GBPUA&T, Pantnagar (Uttarakhand) on April 03-05, 2019.
- Dr. A.P. Dwivedi acted as Rapporteur in Technical Session of Crop Production during Annual Group Meeting on Sugarcane during October 2019 at UAS, Dharwad, Karnataka organized by UAS, Dharwad and ICAR Project Coordinating (Sugarcane) Unit, IISR, Lucknow.
- Dr. Amaresh Chandra received financial assistance award from SERB, New Delhi to attend International Conference at Macau, China held during July 21-24, 2019.
- Dr. Amaresh Chandra was selected as Member Technical Programme Committee of 6th International Conference on Agricultural and Biological Sciences (ABS 2020) to be held in Tokyo, Japan in 2020.
- Dr. P.K. Singh served as Expert Member for Research Advisory Committee of Autumn Season Research Programmes, GSBRI (UPCSR), Seorahi, Kushinagar on September 11-12, 2019.

- Dr. P.K. Singh served as Expert Member in Monitoring Committee for DUS Testing Centres at ICAR-CISH, Lucknow and CSIR-CIMAP, Lucknow on October 29-30, 2019.
- Dr. P.K. Singh served as Expert Member in the Selection Committees for SRF's, YPs at ICAR-CISH, Lucknow.
- Dr. P.K. Singh served as External Expert for Ph.D./ M.Sc. Thesis of different Universities.
- Dr. Sangeeta Srivastava acted as Expert, Selection Committee for JRF, DST-SERB Project at Department of Botany, Lucknow University, Lucknow on July 8, 2019.
- Dr. Sangeeta Srivastava acted as Member, Selection Committee for JRF interview of DST, SERB Project at ICAR-Central Institute for Subtropical Horticulture, Lucknow on April 27, 2019.
- Dr. Sangeeta Srivastava served as Member, National Advisory Board of "National Workshop-cum-Brainstorming Session on Enhancing Productivity & Farmers' Income through Sustainable Sugarcane Production Technologies, organized by NEEDEF, Gorakhpur & ICAR-IISR, Lucknow on June 20, 2019.
- Dr. Sangeeta Srivastava served as Expert Member (DG Nominee) of Assessment Committee for CAS promotion of ARS Scientist (Biotechnology) of ICAR-NRC on Litchi, Muzaffarpur on November 28, 2019.
- Dr. Sangeeta Srivastava admitted as Associate Member of 'The Sugar Technologists Associations of India (ASTA)' on December 06, 2019.
- Dr. Sanjeev Kumar, Principal Scientist (Agri. Biotechnology) served as Expert Member in the Assessment Committee for Probation Clearance of ARS Scientists of ICAR-IIVR, Varanasi on August 28, 2019.
- Dr. Sanjeev Kumar, Principal Scientist (Agri. Biotechnology) served as Expert member (ASRB Nominee) in the Assessment Committee for promotion of Subject Matter Specialists of KVKs of ICAR-IIVR, Varanasi on September 26, 2019.
- Dr. S.N. Singh was nominated as the Member as DDG (Agril. Extension) Nominee for attending Board of Management at Banda University of Agriculture and Technology, Banda on June 13, 2019.
- Dr. S.N. Singh was nominated as the Member, Selection Committee of ICAR-IISR, Lucknow for selection to the post of Young Professional-II for the Division of Crop Production on August 3, 2019.
- Dr. S.N. Singh was nominated as the Member of DPC for clearance of probation period of ICAR-IISR Scientists on August 01, 2019.
- Dr. S.N. Singh was nominated as the Member as DDG (Agril. Extension), ICAR in Interview Board for selection to the post of Associate Professor (Agronomy) at Banda University of Agriculture and Technology, Banda on August 29, 2019.
- Dr. S.N. Singh attended Assessment Committee of CAS as DDG (Crop Science), ICAR Nominee for promotion of Scientists at ICAR-CRIJAF, Barrackpore on September 17, 2019.
- Dr. T.K. Srivastava acted as Nominated Member, Research Advisory Committee of UPCSR, Shahjahanpur for meeting held during September 11-12, 2019 held at GSSBRI, Seorahi.
- Dr. T.K. Srivastava acted as Member, National Monitoring Team constituted for AICRP on Sugarcane.
- Dr. T.K. Srivastava acted as Member, Expert Panel of UPCAR for evaluation of research work done under projects funded by the organization all across the state of Uttar Pradesh.
- Dr. T.K. Srivastava acted as Member, Varietal Identification Committee of the AICRP on Sugarcane.
- Dr. T.K. Srivastava acted as Chairman, DPC for promotion assessment of technical personnel at ICAR-IISS, Mau held on June 28, 2019 and December 20, 2019.
- Dr. T.K. Srivastava acted as Expert Member for training of Master Trainers under Million Farmers' School campaign of Department of Agriculture, Government of UP on October 03, 2019.
- Dr. T.K. Srivastava acted as Principal Investigator (Crop Production), AICRP on Sugarcane.
- Dr. V.P. Singh was invited as Resource Person at Annual Review Meeting of AICRP-Weed Management held on October 15-16, 2019 at AAU, Jorhat, Assam.
- Dr. Amaresh Chandra acted as Organizing Secretary and organized NAAS Lucknow Chapter and Brainstorming Meet at ICAR-CISH, Lucknow on August 20, 2019.
- Dr. A.P. Dwivedi organized International Conference entitled Advances in Agriculture under Changing Climate Scenario for Sustainable Global Development (AAUCSGD-2019) on November 16-17, 2019 at University of Allahabad, Prayagraj as a Co-Convener.
- Dr. P.K. Singh served as Member, Library Committee, Citizen Charter Review & Grievances Redressal Committee and Germplasm Evaluation Committee of ICAR-IISR for the Year 2019.

- Dr. P.K. Singh served as Chairman for Organizing the Selection of the Contingent and arrangements for the Sports Kit for 72 Members to represent ICAR Sports Meet (North Zone)-2019 held at ICAR-IIPR, Kanpur.
- Dr. P.K. Singh served as Chairman, Sports Committee of ICAR-IISR for the Year 2019.
- Dr. Sangeeta Srivastava acted as Member, Publication Committee of ICAR-IISR, Lucknow, 2019-2020.
- Dr. Sangeeta Srivastava nominated as Presiding Officer, Internal Complaints Committee of ICAR-IISR, Lucknow for three years (2019-2022).
- Dr. Sangeeta Srivastava acted as Chairperson, EFC/SFC (2020-25) Plan Committee, IISR and Nodal Officer- SFC/EFC (2020-25) of Commercial Crops of ICAR, New Delhi.

Editors

- Dr. Sangeeta Srivastava served as Chief Editor, Indian Journal of Sugarcane Technology.
- Dr. Sangeeta Srivastava acted as Editorial Board Member of Journal of Environmental Biology.
- Dr. Sangeeta Srivastava acted as Editorial Board Member of Indian Journal of Fundamental and Applied Life Sciences.
- Dr. Sangeeta Srivastava acted as Editorial Board Member of SCIREA Journal of Agriculture (SRA).
- Dr. Sangeeta Srivastava acted as Advisory Board Member of Agrica - An International Journal of Plant Science Researches.
- Dr. Sangeeta Srivastava served as Member, Editorial Board, Proceedings of NISSTA Annual Convention & Sugar Expo (2019) held at NSI, Kanpur.
- Dr. Amaresh Chandra acted as Associate Editor of BMC Plant Biology (Section: Genetics and Crop Biotechnology) since October 2019.
- Dr. Amaresh Chandra acted as Associate Editor of Acta Physiolgiae Plantarum.
- Dr. Amaresh Chandra acted as Consulting Editor of Sugar Tech.
- Dr. Amaresh Chandra acted as Member, Editorial Board of Journal of Sugarcane Research.
- Dr. Amaresh Chandra acted as Member, Editorial Board of Journal of Agricultural Biochemistry.
- Dr. M. Swapna served as Editor of Sugar Tech, a peer reviewed journal related to sugar crops.
- Dr. Rajesh Kumar acted as Chief Editor of Proceedings of Fourth Annual Convention & Sugar Expo-2019 released during Annual Convention of North Indian Sugarcane and Sugar Technologists' Association (NISSTA) held on May 29-30, 2019 at National Sugar Institute, Kanpur.
- Dr. Rajesh Kumar acted as Chief Editor of Souvenir on Sustainable Cane Development and Marketing in Subtropical India released on the occasion of Inaugural Session of the Seminar of North Indian Sugarcane and Sugar Technologists' Association (NISSTA) held on October 11, 2019 at Avadh Sugar and Energy Ltd. Hargaon, Sitapur, UP.
- Dr. S.K. Holkar acted as Editorial Board Member in American Journal of Agriculture and Forestry (AJAF:http://www.sciencepublishinggroup.com/j/ajaf) Science Publishing Group, New York-10018, USA.

Examinership

- Dr. Sangeeta Srivastava acted as External Examiner of preliminary *viva-voce* of a Ph.D. student at C.S. Azad University of Agriculture & Technology, Kanpur on October 31, 2019.
- Dr. M. Swapna served as Examiner for the Ph.D. preliminary *viva-voce* at Department of Genetics & Plant Breeding, CSAUA&T, Kanpur.
- Dr. V.P. Singh acted as Member Selection Committee for Selection of Associate Professor (Agronomy) at Banda University of Agriculture & Technology, Banda (UP) on August 29, 2019.
- Dr. V.P. Singh acted as Member of DPC for Career Advancement of ARS Scientists in the discipline of Agronomy of NBSS&LUP, Nagpur, Maharashtra.
- Dr. V.P. Singh acted as Expert for setting the paper for written examination for the recruitment of Agromet Observer at KVK, ICAR-CIAH, Bikaner.
- Dr. S.N. Singh acted as an External Examiner for selection of post graduate students for international training/assignments at C.S. Azad University of Agriculture and Technology, Kanpur on October 10, 2019.
- Dr. S.N. Singh conducted comprehensive *viva-voce* examination of a Ph.D. Agronomy students of C.S. Azad University of Agriculture and Technology, Kanpur on August 31, 2019.
- Dr. T.K. Srivastava acted as Thesis Examiner for M.Sc. (Ag) Agronomy of ICAR-IARI, New Delhi and Ph.D. (Agronomy) for UAS, Dharwad.
- Dr. R.R. Verma worked as paper setter for C.S. Azad University of Agriculture and Technology, Kanpur.
- Dr. Radha Jain acted as external examiner for Ph.D. Thesis evaluation for CSAUA&T, Kanpur.

Reviewer

- Dr. Amaresh Chandra screened and evaluated the projects submitted to SERB (DST), Govt. of India (Online).
- Dr. Amaresh Chandra acted as Reviewer of research articles submitted to journals like Plant Cell Physiology, SugarTech, Acta Physiolgiae Plantarum, BMC Plant Biology, 3 Biotech *etc.*
- Dr. Sangeeta Srivastava acted as Reviewer of research papers submitted to the journals like Nature Scientific Reports, PLOS One, Euphytica, Molecular Biology Reports, Plant Growth Regulation, Plant Breeding, Plant Genetic Resources, South African Journal of Botany, 3 Biotech (BITC), The Scientific World Journal, Journal of Genetics, Sugar Tech, J. Env. Biol. and World Journal of Agricultural Sciences.
- Dr. Sangeeta Srivastava acted as Reviewer of Book Proposal on "Microbial Genomics in Sustainable Agroecosystems" by Springer India, New Delhi.
- Dr. T.K. Srivastava received Certificate of Outstanding Contribution in Reviewing by the International journal Agriculture, Ecosystems and Environment (Elsevier).
- Dr. T.K. Srivastava reviewed papers for Indian Journal of Agricultural Sciences, Sugar Tech, Indian Journal of Agronomy, Agriculture, Ecosystem and Environment (Elsevier publication) and Indian Journal of Sugarcane Technology.
- Dr. M. Swapna served as Reviewer for peer reviewed journals Physiology & Molecular Biology of Plants, Sugar Tech and Indian Journal of Sugarcane Technology.
- Dr. Sanjeev Kumar served as Reviewer of international journals, Scientia Horticulturae (Elsevier), Physiology Molecular Biology of Plants (Springer), Sugar Tech (Springer), International Journal of Vegetable Science (Taylor & Francis), and Current Science (India).
- Dr. Radha Jain reviewed research manuscripts received from JEB, IJST, Indian Farming, Sugar Tech Journals.
- Dr. Radha Jain reviewed a research project submitted to CSTUP as external expert (Online).
- Dr. A.K. Sharma was the reviewer for a project submitted to ICAR (Project No. 26) Economic Empowerment of Rural Women through Agro-processing and Bakery Value Addition Centres in Different Districts of the State (Karnataka) for funding by Bakery and Value Addition Centre of UAS, Bangalore, Karnataka.
- Dr. S.K. Holkar acted as reviewer for the Journal of Environmental Biology (Publisher: Triveni Enterprises, Lucknow) and Sugar Tech (Publisher: Springer).
- Dr. Y.E. Thorat acted as referee for the Pravara Science Fiesta-2019 organized by Department of Botany and Science Association of PVP College of Arts, Science and Commerce, Pravaranagar (MS), India.

Project sanctioned

- An externally funded project entitled "Source-sink dynamics in sugarcane – a global transcriptome analysis to decipher factor(s) controls sucrose content in cane stalk/culm" (₹ 30,35,059/- for three years) from SERB, New Delhi (PI: Dr. Amaresh Chandra and Co-PI: Dr. Radha Jain).

Ph.D. awarded to student

- Ms. Kriti Roopendra has been awarded Ph.D. on "Transcriptomic analysis of source-sink dynamics associated with sugar accumulation in sugarcane" on July 15, 2019 from BBA University, Lucknow. She has done her work at ICAR-IISR, Lucknow under CSIR Fellowship under Co-supervisor of Dr. Amaresh Chandra.

Overseas visit (Deputation)

- Dr. Amaresh Chandra visited Macau, China and presented a paper (July 21-24, 2019).
- Dr. M. Swapna, visited Tacuman, Argentina and presented a paper in 30th ISSCT Congress held their during September 1-5, 2019.
- Dr. A.K. Singh visited China and attended Seminar on Agricultural Technology Innovation for South Asian Countries during May 27-June 4, 2019.

CHAPTER 15

Publications

Research Papers

Chandra A, Roopendra K and Verma I. 2019. Transcriptome analysis of the effect of GA_3 in sugarcane culm. *3 Biotech*. **9**: 376.

Gangwar LS and Pathak AD. 2019. Impact of jaggery entrepreneurship on enhancing sugarcane farmers' income: A study of Uttar Pradesh. *Agricultural Economics Research Review* **32** (Conf.): 236.

Gangwar LS and Pathak AD. 2019. Integration of farm and non-farm activities for farmers' welfare and enhancing farm income in sugarcane based farming system-An approach in Public- Private Partnership mode. *Indian Journal of Agricultural Economics* **74**(3): 436.

Gujjar RS and Supaibulwatana K. 2019. The mode of cytokinin functions assisting plant adaptations to osmotic stresses. *Plants* 8(12): 542.

Gujjar RS, Pathak AD, Karkute SG and Supaibulwatana K. 2019. Multifunctional proline rich proteins and their role in regulating cellular Pro level in plants under stress. *Biologia Plantarum* 63(1): 448-454.

Jain Radha, Singh Anshu, Singh SP, Chandra A and Pathak AD. 2019. Morphological and anatomical aberrations induced by waterlogging in sugarcane. *Journal of Environmental Biology* **40**: 634-640.

Jain Radha, Singh Anshu, Singh RK, Singh SP and Chandra A. 2019. Growth hormones in combination with essential nutrients impacting growth, yield and juice quality attributes of sugarcane. *Indian Journal of Sugarcane Technology* **34**(01): 26-35.

Kapur R, Singh J, Swapna M, Pandey DK, Kumar S, Singh PK. Lal RJ, Singh MR, Singh RK, Kumar S and Pathak AD. 2019. Sugarcane variety "CoLk 11203" (Ikshu-5). *Indian Journal of Genetics and Plant Breeding* **79**(2): 517.

Khan MS, Singh A, Singh D, Singh RK and Kumar S. 2019. Fingerprinting tissue culture-raised sugarcane plantlets using inter simple sequence repeat markers for genetic fidelity testing. *Indian Journal of Sugarcane Technology* **34**(1): 21-25.

Kumar S, Singh J, Singh PK and Pandey DK. 2019. 'CoLk 11206' (*Ikshu*-4)- a high yielding mid-late sugarcane variety for North West Zone. *Indian Journal of Sugarcane Technology* **34**(1): 7-11.

Misra V, Shrivastava AK, Mall AK, Solomon S and Ansari MI. 2019. Can sugarcane cope with increasing atmospheric CO_2 concentration? *Australian Journal of Crop Science* **13**(5): 780-784.

Misra V, Solomon S, Mall AK and Ansari MI. 2019. Minimisation of post-harvest sucrose losses in drought affected sugarcanes using chemical formulation. *Saudi Journal of Biological Sciences* **27**(1): 309-317.

Misra V, Mall AK, Hasan A and Ansari MI. 2019. Red rot: Threatening disease of sugarcane. *Journal of Biological and Chemical Research* **36** (1: Part D): 197-204.

Pandey V, Banerjee N, Singh A, Siraree A, Singh RK and Kumar S. 2018. Genetic diversity among popular varieties and promising genotypes of sugarcane (*Saccharum* sp. hybrid) using simple sequence repeat markers. *Indian Journal of Sugarcane Technology* **33**(2): 69-76.

Pradhan Neha, Kumar Dilip, Pisalkar PS and Singh Priyanka. 2019. Effect of microwave on sugarcane juice preservation. *Food Science Research Journal* **10**(1): 57-62.

Pradhan Neha, Kumar Dilip, Singh Priyanka and Pisalkar PS. 2019. Status of sugarcane juice preservation processess and technologies: A review. *International Journal of Chemical Studies* **7**(4): 2720-28.

Sah AK and Pathak AD. 2019. Doubling farmers' income in cane growing areas: Success story of sugarcane sector. *Indian Journal of Extension Education* **55**(3): 19-24.

Sahu T, Khokhar D, Anwar SI, Paikara D and Paikra SS. 2019. Performance evaluation of sugarcane cleaner-cum-washer for jaggery production. *Int J of Current Microbiology and Applied Sciences* **9**: 78-84.

Sharma L, Shukla SK, Jaiswal VP and Sharma KK. 2019. Characterization of general beneficial bacterial diversity for plant growth promoting attributes associated with rice rhizosphere. *Journal of Environmental Biology* **40**: 1-8.

Shukla SK, Yadav SK, Dwivedi AP and Singh GK. 2019. AICRP on Sugarcane: Salient achievements and future directions on soil health and crop nutrition. *Indian Journal of Fertilisers* **15**(4): 430-445.

Singh AK, Mall AK and Singh PK. 2019. Genetic study for epistatic gene effects for major yield contributing

traits against drought in rice. *Journal of Applied and Natural Science* **11** (4): 755-761.

Singh D, Pandey R, Srivastava S, Tiwari A, Vandana P, Singh D and Pallavi. 2019. Studies on diversity of rhizospheric microflora in relation to different sugar profile varieties of sugarcane and *Saccharum* species level clones. *Indian Journal of Sugarcane Technology* **34**(1): 41-44.

Singh NK, Singh AK, Singh AK, Misra V and Mall AK. 2019. Estimates of genetic parameters, components of variance and thier magnitude in rice (*Oryza sativa* L.). *Plant Archives* **19** (Supplement 1): 1105-1107.

Singh NK, Singh AK, Singh AK, Misra V and Mall AK. 2019. Heterosis breeding in rice (*Oryza sativa* L.) for quantitative traits. *Plant Archives* **19** (1): 544-548.

Singh J, Kumar S, Singh PK, Pandey DK, Singh RK, Lal RJ, Srivastava TK and Pathak AD. 2019. Sugarcane variety "CoLk 11206" (*Ikshu*-4). *Indian Journal of Genetics and Plant Breeding* **79**(2): 518.

Singh RK, Sharma AK, Singh YP and Singh VK. 2019. Dynamics of grazing land resource availability and utilization in central region of Uttar Pradesh. *Journal of Community Mobilization and Sustainable Development* **14**(2): 318-324.

Singh SP, Singh MK, Singh Mukesh K and Ekka U. 2019. Ergonomics for gender friendly farm equipment to enhance better human-machine interaction. *RASSA Journal of Science for Society* **1**(1&2): 54-59

Singh SP, Singh Mukesh K, Ekka U and Singh MK. 2019. E-powered multi-purpose two-row seeder for smallholders. *Indian Journal of Agricultural Sciences* **89**(12): 2091–2095.

Srivastava S and Gupta PS. 2019. Extracting gDNA suitable for molecular applications from sugarcane, and its phytopathogens. *International Journal of Current Microbiology and Applied Sciences* **8**(6): 2670-2678.

Srivastava S and Kumar P. 2019. Potential of sugarcane in modern energy development in India. *Trends in Biosciences* **12**(12): 870-873.

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CHAPTER 16

Technical Programme

Technical Programme

Project Code	Title of the project
Division of Crop Improvement	
B 1.7	Collection, maintenance, evaluation and documentation of sugarcane germplasm under sub-tropical conditions (P.K. Singh and Sanjeev Kumar, 01/95-LT)
B 1.8	Defining ideotypes in sugarcane for moisture deficit conditions (A.K. Mall, D.R. Malaviya and S.P. Singh; 01/17-12/21)
B 2.13	Development of sugarcane varieties for sub-tropics (Sanjeev Kumar, P.K. Singh and T.K. Srivastava; 10/03-LT)
B 2.15	Developing sugar beet varieties suitable for Indian agro-climates (A.D. Pathak, A.K. Mall and Arun Baitha; 09/08- LT)
B 2.17	Development of sugarcane clones/varieties for North Central Zone (A.K. Mall, A.D. Pathak, D. Singh, Arun Baitha, M.K. Tripathi and C.K. Gupta; 10/18-09/28)
B 3.19	Mapping of loci linked to sugar content in sugarcane (M. Swapna; 12/09-03/20)
B 3.21	Production of disease free and genetically pure seed cane through tissue culture techniques (Sanjeev Kumar and S.K. Holkar; 11/13-LT)
B 3.22	Development of *in vitro* conservation protocol using slow-growth tissue culture techniques in sugarcane (Sanjeev Kumar (Biotech.); 03/15-03/20)
B 3.23	Profiling and prediction of small RNA transcriptomes in sugarcane in sugarcane inoculated with red rot pathogen (Sangeeta Srivastava, A.D. Pathak and Dinesh Singh, 10/15-10/20)
AICRP on Sugarcane	
B 1.1	Evaluation of early maturing sugarcane clones of North West Zone (Sanjeev Kumar and P.K. Singh, 02/09-LT)
B 1.2	Evaluation of mid-late sugarcane clones of North West Zone (Sanjeev Kumar and P.K. Singh, 02/09- LT)
B 1.3	Evaluation of sugarcane clones under Zonal Varietal Trials for North Central and Eastern Zone (A.K. Mall and A.D. Pathak; 02/09 to LT)
Externally funded	
DBT	Accredited Test Laboratory (ATL) under National Certification System for Tissue Culture Raised Plants (NCS-TCP) Coordinator: Sanjeev Kumar (Biotech.), PIs: Sanjeev Kumar and Dinesh Singh; 03/15-03/20, Budget : ₹ 103.00 lakh
DST-SERB	Genomic selection based accelerated breeding in sugarcane (*Saccharum* species complex) with special reference to sugar content and red rot resistance [Sanjeev Kumar (Biotech.), 06/18-06/21; Budget : ₹ 49.78 lakh]
DST WOS-A	Investigating sucrose accumulation through RNA-seq bulked segregant analysis in sugarcane (PI: Nandita Banerjee, Mentor: Sanjeev Kumar; 06/18 - 06/21, Budget : ₹ 30.0 lakh)
PPV&FRA	Central Sector Scheme for PPV&FRA (P.K. Singh, 2006-LT)
ICAR	ICAR seed project "Seed production in agricultural crops" (P.K. Singh and Sanjeev Kumar, 2006-LT)
Division of Crop Production	
A 1.1.33	Biology and management of binding weed *Ipomoea spp.* in sugarcane (V.P. Singh, K.K. Singh, T.K. Srivastava, Dilip Kumar, S.P. Singh, V.P. Jaiswal and A.P. Dwivedi; 2017–2022)
A 1.1.34	Improved agronomic interventions for enhancing productivity of ratoon crop (Dileep Kumar, V.P. Singh, K.K. Singh, Mona Nagargade and S.R. Singh; 04/19-03/24).
A 1.2.31	Studies on effect of tillage and management practices on rice-wheat-sugarcane-ratoon-wheat in Conservation Agriculture (V.K. Singh, V.P. Singh, S.K. Shukla, V.P. Jaiswal, A.K. Singh (Engg.), Dinesh Singh and S.N. Sushil; 2017–2022)
A 2.37	Sugarcane productivity in relation to initial soil organic carbon content and nutrient management in sub-tropical inceptisol (T.K. Srivastava, S.R. Singh, Pushpa Singh and R.R. Verma; 3/15 - 6/19)
A 2.38	Soil quality assessment under different sugarcane growing systems (S.R. Singh, T.K. Srivastava, M.K. Tripathi, R.R. Verma, Pushpa Singh, S.N. Singh, A.K. Singh (Agronomy) and R.S. Dohare; 03/15-03/20)
A 2.39	Synchronizing nutrient supply with crop demand under drip fertigation for upscaling nutrient use efficiency in sugarcane (Plant) ratoon system (K.K. Singh, S.R. Singh, V.P. Singh, S.K. Shukla and Rajendra Gupta; 2017-2022)

Project Code	Title of the project
A 2.40	Effect of silicon nutrition on growth, yield. juice and soil quality of sugarcane in sub-tropics (M.K. Tripathi, S.R. Singh, C. Gupta, S.K. Shukla, S.N. Singh, A.P. Dwivedi & V.K. Singh: 4/19-03/24)
A 2.41	Management of bio-resources for enhancing sugarcane productivity and soil health (A.P. Dwivedi, V.P. Singh, S.K. Shukla, M.K. Tripathi, V.K. Singh, K.K. Singh, S.R. Singh and Lalan Sharma: 10/18-09/23)
A 2.42	Improving soil health and sugarcane ratoon productivity through application of microbial consortia (V.P. Jaiswal, S.K. Shukla, T.K. Srivastava, Lalan Sharma, D.N. Borase and S.K. Yadav: 02/19-01/24)
A 2.43	Developing scientific aids for site specific nutrient management through variable mapping of soil properties in sugarcane growing soils (R.R. Verma, T.K. Srivastava, Pushpa Singh and S.R. Singh: 04/19 -03/24)
A 3.24	Enhancing system productivity and profitability of wide row planted autumn sugarcane through intercropping of high value crops (C. Gupta, A.K. Singh (Agron.), M.K. Tripathi, S.R. Singh, S.P. Singh, A.K. Singh (AE), V.P.Singh and S.K.Shukla; 03/19-02/23)
A 3.25	Diversification of sugarcane based cropping system with medicinal and aromatic plants in sub-tropical India (S.K. Yadav, S.K. Shukla, V.P. Jaiswal, Saudan Singh (CSIR-CIMAP, Lucknow) and Arun Baitha: 03/19-02/23)
	Nano-urea to improve nitrogen use efficiency in sugarcane (Mona Nagargade, D. Joshi, Dilip Kumar, A. Chandra, V. P. Jaiswal and S.R. Singh; 08/19-07/24)
A ET 1.1	Modulating application of sugarcane production technologies for harnessing production and productivity potential in farmers' field perspective (R.S. Dohare, T.K. Srivastava, Rajesh Kumar, Kamta Prasad, S.N. Singh, M.R. Singh and Niranjan Lal; 04/15–03/20)
A 4.10	Developing sugarcane based Integrated Farming System Models for small farm holders of sub-tropical India (A.P. Dwivedi, T.K. Srivastava, S.K. Shukla, Niranjan Lal, A.K. Dubey, A.K. Sharma, Akhilesh Kumar Singh, Rakesh Kumar Singh, S.P. Singh and A.D. Pathak; 2016-LT)
Exp Trial	Evaluation of the effect of bio-stimulator on growth, yield and juice quality of sugarcane (A.P. Dwivedi, V.K. Singh and V.P. Singh; 03/17-03/19)
AICRP on Sugarcane	
AS 68	Impact of integrated application of organics and inorganics in improving soil health and sugarcane productivity (C. Gupta, T.K. Srivastava and S.R. Singh, 2014-2019)
AS 71	Carbon sequestration assessment in sugarcane based cropping system (V.P. Jaiswal, S.K. Shukla, V.P. Singh; 2016-2019)
AS 72 (A)	Agronomic performance of elite sugarcane genotype (Early) (V.P. Singh and S.K. Shukla; 2016- LT)
AS 72 (B)	Agronomic performance of elite sugarcane genotype (Mid-late) (K.K. Singh and V.P. Singh; 2016-LT)
AS 73	Assessment of climate change impact on sugarcane productivity (R.R. Verma and T.K. Srivastava; 2018-LT)
AS 74	Evaluation of sugarcane varieties for drought tolerance (V.K. Singh, K.K. Singh and V.P. Singh; 2018-LT)
AICRP on STCR	
STCR	Soil test and resource based integrated plant nutrient supply system for sustainable sugarcane production (S.R. Singh, T.K. Srivastava, R.R. Verma and S.S. Hasan; 2014- LT)
AICRP on Groundnut	
	Effect of water and nutrient management in sugarcane-groundnut intercropping during spring season (M.K. Tripathi, C. Gupta and A.P. Dwivedi; 03/19-03/22)
Contract Research	
Sumitomo Chemical (India)	Bio-efficacy & phyto-toxicity evaluation of 'Flumioxazin 50% SC' against weeds in sugarcane and its effect on succeeding crop (V.P. Singh, K.K. Singh, V.P. Jaiswal and S.K. Shukla; 10/16-8/19)
ISK BioSciences India Pvt. Ltd.	Bio-efficacy evaluation of SL160 10% herbicide against weed control of sugarcane (V.P. Singh, A.P. Dwivedi, V.K. Singh and K.K. Singh; 03/17 -09/19)
Meghmani Organics	Bioefficacy evaluation of Atrazine 50% WDG herbicide against weed complex of sugarcane (K.K. Singh, V.P. Singh and V.P. Jaiswal; 03/17 - 09/19)
ADAMA Ind. Pvt. Ltd., Hyderabad	Bio-efficacy evaluation of Ametryn 80% WDG herbicide against weed complex of sugarcane (V.P. Singh, V.K. Singh, K.K. Singh and A.P. Dwivedi, 03/17-9/19)
United Phosphorus Ltd., Mumbai	Bio-efficacy & phyto-toxicity evaluation of UPH 114b against weeds in sugarcane (V.P. Jaiswal, V.P. Singh, Lalan Sharma and S.K. Shukla; 2019-2021)
Division of Crop Protection	
EM 01	Survey and surveillance of insect pests and diseases of sugarcane in sub tropical India (M.R. Singh and all the Scientists of Crop Protection Division; Duration: LT)

Project Code	Title of the project
M 5.10	Management of Yellow Leaf Disease (YLD) of sugarcane through thermotherapy (Dinesh Singh and S.K. Holkar, 05/15-04/21)
M 17	Evaluation/screening of sugarcane germplasm against red rot and smut (M.R. Singh, Dinesh Singh and S.K. Duttamajumder, 1992-93-LT)
M 15.6	Enhancing efficacy of *Trichoderma* based red rot management system (Deeksha Joshi and Pushpa Singh, 04/12-03/20)
M 15.7	Management of Pokkah boeng disease of sugarcane (Lalan Sharma, S.K. Shukla, V.P. Jaiswal and M.R. Singh: 03/19-02/23)
Ento 15.3	Isolation, identification and synthesis of sex pheromones lures for the management of major borers of sugarcane (M.R. Singh, Pushpa Singh, A. Baitha, S.N. Sushil and A.K. Jaiswal: 04/19-03/22)
Ento 15.4	Dispersal, host location, kairomonal effect and recovery of bio-agents *Trichogramma chilonis* and *Tetrastichus howardi* (Arun Baitha, M.R. Singh, A.K. Jaiswal, S. Roy and S.N. Sushil: 10/18-09/22)
Ento 2.1.2	Developing arthropods based soil health indicator for subtropical sugarcane ecosystem (Sharmila Roy, A.K. Jaiswal, D. Joshi and S.R. Singh: 10/18-09/23)
Ento 4.2.1	Development of eco-friendly technologies for the management of termites in sugarcane (S.N. Sushil, A.K. Jaiswal, S. Roy and D. Joshi: 10/18-09/22)
AICRP (S)	**Plant Pathology**
PP 14	Identification of pathotypes in red rot pathogen (Dinesh Singh and Lalan Sharma)
PP 17	Evaluation of zonal varieties against red rot, smut and wilt (Dinesh Singh and Lalan Sharma)
PP 22	Survey of sugarcane diseases naturally occurring in the area on important varieties (Dinesh Singh and Lalan Sharma)
Entomology	
E 4.1	Evaluation of varieties/genotypes for their reaction against major insect pests (M.R. Singh, A. Baitha and S.N. Sushil)
E. 30	Monitoring of insect pests and bio-agents in sugarcane agro-ecosystem (M.R. Singh, A. Baitha and S.N. Sushil)
E. 34	Standardization of simple and cost effective techniques for mass multiplication of sugarcane bio-agents (M.R. Singh, A. Baitha and S.N. Sushil)
E.39	Pilot evaluation of water less pheromone trap and water basin pheromone trap against sugarcane borers (Arun Baitha and M.R. Singh)
Contract Project	
Bayer Crop Science, Ltd	Bio-efficacy of Vayego Superb (Tetraniliprole 0.4% +Fipronil 0.6% Gr against early shoot borer, top shoot borer and white grub in sugarcane sponsored by Bayer Crop Science, Ltd., Mumbai, Budget ₹ 9.0 lakh.
Division of Plant Physiology and Biochemistry	
PB 28	Minimizing post-harvest sucrose deterioration and its molecular assessment in sugarcane (A. Chandra, Radha Jain and D.N. Borase; Duration: 04/12-03/22)
PB 29	Physiological and molecular base of multiple abiotic and biotic stress tolerance in sugarcane (S.P. Singh, Radha Jain, A. Chandra, A.K. Mall and A.D. Pathak, 04/17-03/22)
PB 30	Genome sequencing of red rot pathogen of sugarcane (A. Chandra, Sanjeev Kumar (Biotech.), D. Singh and Deeksha Joshi, 04/17-03/22)
PB 31	Understanding mechanisms of sugar accumulation and WUE in sugarcane through physio-bio-chemical studies (C.K. Gupta, S.P. Singh, Rajeev Kumar, A. Chandra, A.K. Mall, Bhupinder Singh, Rajesh Kumar, R Jain and A.D. Pathak; Duration: 10/18-09/22)
PB 32	Evaluation of silica application in relation to moisture stress, disease and pest tolerance and productivity in sugarcane (Rajeev Kumar, A.D. Pathak, R. Jain, C.K. Gupta, A. Chandra, Lalan Sharma, R.R. Verma, Pushpa Singh and M.R. Singh: 03/19-02/24)
PB 33	Process development for enhancing ethanol recovery from sugarcane trash and 'B heavy' molasses (Pushpa Singh and Rajeev Kumar: 04/19-03/24)
PB 34	Assessment of scope for invigoration of biomass dynamics during sugarcane growth cycle through plant growth regulators (Pushpa Singh, R. Jain and Rajeev Kumar: 04/19-03/24)
Inter-Institutional Project	Screening and identification of sugarcane lines tolerant to water-logging and their physio-biochemical investigation (Radha Jain, A.D. Pathak, A. Chandra, S.P. Singh, M. Swapna, V.K. Srivastava, M. Ramadurai, 2013-2021)
Externally Funded Projects	
DST-SERB	Source-sink dynamics in sugarcane-a global transcriptome analysis to decipher factor(s) controls sucrose content in cane stalk/culm (A. Chandra and R. Jain; Budget : ₹ 30.35 lakh)
Division of Agricultural Engineering	
AE 1.19B	Development of two row disc type ratoon management device with and without stubble shaving attachments (A.K. Singh and Sukhbir Singh; 09/16-08/19)

Project Code	Title of the project
AE 1.52	Development and evaluation of tractor operated multipurpose tool frame with attachments for sugarcane (Sukhbir Singh and A.K. Singh, 10/15-09/20)
AE 1.23	Development of cane node planter (A.K. Singh and S.N. Singh; 09/16 -08/19)
AE 1.81	Development of sugarcane trash management machinery (M.K. Singh, A.K. Singh and R.D. Singh: 09/18-08/21)
AE 6.8	Sustaining sugarcane yield under multiple ratooning through drip irrigation (Rajendra Gupta; 03/16- 03/22)
AE 7.1.1	Refinement of sugarcane cleaner cum washer for jaggery (S.I. Anwar, Dilip Kumar and R.D. Singh, 11/16-10/20)
AE 7.6.1	Development of integrated drying system for jaggery drying (R.D. Singh, A.K. Singh, S.I. Anwar and Dilip Kumar; 11/16–11/19)
AE 7.6.2	Development of a jaggery furnace with efficiency boosting device (S.I. Anwar, 04/12-03/20)
AE 7.6.3	Development of small powder jaggery cubes (Dilip Kumar, S.I. Anwar and R.D. Singh; 08/19-07/21)
AE 7.6.4	Process protocol for enhancing the shelf life of sugarcane juice (Dilip Kumar; 08/19-07/22)
Inter-institutional Collaborative Project	
IISR-SBI/2019/01	Inter-institutional collaborative project on testing and evaluation of selected IISR sugarcane machineries under tropical condition (A.K. Singh (IISR) and T. Arumuganathan (SBI); 02/19-01/22)
AICRP on Farm Implements and Machinery	
FIM/IISR/PMW/86	Manufacturing of prototypes for conducting field adoptability trials under varying agro-climatic and soil conditions (A.K. Singh; 04/86-LT)
FIM/IISR/PFT/2015/01	Prototype feasibility trial of Pant-ICAR sub-soiler-cum-differential rate fertilizer applicator (R.D. Singh, Sukhbir Singh and A.K. Singh; 04/16-03/19)
FIM/IISR/FLD/2017/01	IISR tractor operated disc type ratoon management device (A.K. Singh, Sukhbir Singh and A.K. Sah; 04/17–03/20)
FIM/IISR/FLD/2017/02	IISR tractor operated deep furrow sugarcane cutter planter (A.K. Singh, Sukhbir Singh and R.D. Singh; 02/17–03/20)
FIM/IISR/FLD/2017/03	IISR tractor operated sugarcane trench planter (A.K. Singh, Sukhbir Singh and R. Gupta; (04/17-03/20)
FIM/IISR/FLD/2017/04	IISR tractor operated deep furrow sugarcane cutter planter/trench planter-cum-multicrop raised bed seeder (A.K. Singh and Sukhbir Singh; 04/17-03/20)
FIM/IISR/FLD/2017/05	IISR tractor operated deep furrow sugarcane-cum-potato planter (A.K. Singh; 11/17- 03/20)
AICRP on Post Harvest Engineering Technology (PHET)	
LKO/PHTS/16/01	Development of sugarcane juice extractor for household use (Dilip Kumar and S.I. Anwar; 01/16-12/19)
Externally funded projects	
ICAR	Agri-consortia research platform on water (Rajendra Gupta, T.K. Srivastava, Pushpa Singh, S.R. Singh, R.R. Verma and S.N. Singh, 12/15-03/19, Budget : ₹ 31.0 lakh)
UPCAR	Development and dissemination of drudgery reducing farm tools and equipment for sugarcane for small and marginal farmers of UP- Centre of Excellence in Farm Machinery (Sukhbir Singh, A.K. Singh and R.K. Singh, 05/17–05/22, Budget : ₹ 40.06 lakh)
UPCST	Development of process technology (protocol) for manufacturing of protein rich jaggery using natural source (S.I. Anwar and R.D. Singh; 07/18-07/21, Budget ₹ 10.84 lakh)
RKVY (U.P. Govt)	Establishment of quality jaggery production-cum-training unit in selected districts of Uttar Pradesh for income generation and entrepreneurship development (Dilip Kumar, A.D. Pathak, A.K. Singh and A.K. Mall, 04/18–03/20, Budget : ₹ 220 lakh)
NSC	Entrepreneurship development and income enhancement of sugarcane farmers in Chakia, Kotwa and Arirajpur (Bihar) through establishment of IISR Model jaggery unit (Dilip Kumar, A.D. Pathak, A.K. Singh, S.I. Anwar and S.N. Singh; 04/18-03/19; Budget ₹ 36 lakh)
DST funded project under Women Scientist Scheme B (WOS B)	Modified atmosphere packaging of sugarcane juice in closed system (Priyanka Singh, Mentor-Dilip Kumar; 04/18-03/ 19)
Extension and Training Unit	
ET 1.14	Entrepreneurship development for sugarcane seed production and multiplication (A.K. Sah, S.N. Singh, Sanjeev Kumar, S.N. Sushil and Kamta Prasad, 10/12–10/19)
ET 1.15	An analysis of gender perspective in sugarcane cultivation (Kamta Prasad, R.S. Dohare, A.K. Sah, Rajesh Kumar and A.K. Sharma; 01/17–12/20)
ET 1.16	Technology and information utilization pattern among the sugarcane growers (Barsati Lal, K Prasad, R.S. Dohare, A.K. Sah, R. Gupta and L.S. Gangwar; 10/18-09/23)
Economics & Statistics/AKMU/PME Cell	
AES 4.15	Development of data mining and presentation tools in sugarcane (S.S. Hasan, Rajesh Kumar and L.S. Gangwar; 04/12-03/21)
AES. 4.16	Factors contributing to economic viability of sugar mills and energy production complexes in India (L.S. Gangwar, S.S. Hasan and A.K. Sah; 03/15-03/20)

Project Code	Title of the project
AES 4.17	Impact of IISR technologies in sustaining sugarcane production in India (A.K. Sharma, T.K. Srivastava, A.K. Singh, A.D. Pathak and M.R. Singh, 04/15-03/20)
AES 4.18	Estimation of techno-economic feasibility of sugar beet cultivation for sugar and ethanol production in India (A.K. Sharma, T.K. Srivastava and A.D. Pathak; 10/15-06/19)
AES 4.19	Online database and mixed model analysis of sugarcane varieties tested/released in India (Rajesh Kumar, S.S. Hasan and A.D. Pathak; 04/17-03/21)
AES 4.20	Development of web based reporting system for the trials of AICRP on Sugarcane (S.S. Hasan, S.K. Shukla, A.D. Pathak and Rajesh Kumar, 10/16-09/19)
AES 4.21	Efficiency of designs in sugarcane field experiments (RCBD *vs* Alpha design) (Rajesh Kumar, R. Gupta, A.D. Pathak, A.K. Sachan and B.B. Joshi; 08/19-07/22)
AES 4.22	Development of district-level database on sugarcane growth and sustainability (A.K. Sharma and L.S. Gangwar; 08/19-07/22)
Exploratory study	Indian perspective of sugarcane research and policies (A.K. Sharma and A.D. Pathak; 08/18-08/19)
IISR Biological Control Centre, Pravaranagar	
EM 01	Survey and surveillance of insect-pests and diseases of sugarcane in sub-tropical area (M.R. Singh, HoD and all the Scientists of ICAR-IISR Biological Control Centre, Pravaranagar; Duration: Long Term)
M 5.9	Genetic diversity and transmission of pathogens causing Yellow Leaf Disease in sugarcane (S.K. Holkar, Arun Baitha and Sanjeev Kumar (Biotech.); Duration: 04/15–03/20)
BCC 1.1	Bio-prospecting of entomopathogenic bacteria for management of white grubs infesting sugarcane (D.N. Borase, S.N. Sushil, D. Joshi, S.K. Holkar and Y.E. Thorat: 08/18-07/23)
BCC 1.2	Utilization of entomopathogenic nematodes against white grubs infesting sugarcane (Y.E. Thorat, S.N. Sushil, D.N. Borase and S.K. Holkar: 08/18-07/23)
Externally funded project	
RKVY (Maharashtra)	Establishment of biological control laboratory for mass production of biological agents against sugarcane insect pests and diseases and dissemination of technology for enhanced cane and sugar productivity in Maharashtra (IISR, Lucknow) (S.N. Singh, M.R. Singh, Deeksha Joshi, Arun Baitha, S.K. Holkar, D.N. Borase and Y.E. Thorat**;** Duration: 04/17-04/19; Budget : ₹ 5.0 crore;).
Contract Research Project	
BASF	Evaluation of bioefficacy and phytotoxicity pre-emergent application of Saflufenacil 68 g/l + Dimethanamid - P 600 g/l EC (Integrity 668 g/l EC) against weeds in sugarcane and its effect on succeeding crop, (S.K. Holkar, D.N. Borase and Y.E. Thorat; 04/18-03/20; Budget: ₹ 15 lakh)

CHAPTER 17

Review, Monitoring and Evaluation

RAC Meeting

XXV meeting of Research Advisory Committee of the ICAR-IISR, Lucknow was held on May 02-03, 2019 under the chairmanship of Dr Y.S. Nerkar, Former Vice-Chancellor, MPAU, Rahuri. Dr. S.R. Maloo, Ex. Director Research, MPUAT, Udaipur; Dr. S. Sithanantham, Director, Sun Agro Biotech Research Centre, Chennai; Dr. Surendra Singh, Ex. Project Coordinator (FIM); Dr. Rajvir Singh, Ex. Member, CACP, Govt. of India & Ex. Head, Division of Social Sciences, ICAR-NDRI, Karnal; Dr. Anoop Kumar, General Manager (Cane), Biswan Sugar Mill, Sitapur; Farmers representative, Sh. Shivendra Mohan Dubey from Kanpur Dehat besides; Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow; Dr. A.K. Sharma, Principal Scientist (Ag. Economics), ICAR-IISR, as Member Secretary, Project Coordinator (Sugarcane), Heads of the Divisions and Scientists from ICAR-IISR were also present.

Dr. A.D. Pathak, Director, IISR made a presentation on sugarcane scenario in the country and efforts of IISR. Dr. L.S. Gangwar, Principal Scientist and I/c, PME Cell presented an overview of the activities of Prioritization, Monitoring and Evaluation (PME) Cell. Dr. D.R. Malaviya, Head, Division of Crop Improvement; Dr. V.P. Singh, Head, Division of Crop Production; Dr. M.R. Singh, Head, Division of Crop Protection; Dr. Radha Jain, Head, Division of Plant Physiology and Biochemistry; Dr. A.K. Singh, Head, Division of Agricultural Engineering; Dr. A.K. Mall, Senior Scientist & In-charge IISR Regional Centre, Motipur (Bihar); Dr. S.N. Singh, Pr. Scientist (Agron), Incharge Head, KVK, Lucknow and Nodal Officer, IISR, Biological Control Centre, Pravaranagar; Dr. A.K. Sah, Principal Scientist & Incharge, Training & Extension Unit; Dr. Rajesh Kumar, Principal Scientist and Incharge, AKMU and

Dr. A.K. Sharma presented the research highlights. The RAC appreciated the efforts of the Scientists of the Institute and made following major recommendations:

- Ongoing research on developing climate resilient varieties based on *per se* performance needs to be strengthened by selections under abiotic stress conditions, especially using the molecular tools.
- In the varietal improvement programme, emphasis should be given to breed varieties having higher nutrient use efficiency.
- An experiment should be taken up on increasing nitrogen use efficiency so as to economize the fertilizer usage. Component of the organic source of nitrogen be included.
- Research on new races of red rot disease should be taken up.
- For the extension of shelf life of bio-agents like *Trichogramma japonicas* and *T. chilonis* (local strains), work may be initiated through diapauses induction regime.
- Research on mass trapping of four major borers should be carried out with suitable refinements for sex pheromones.
- To mitigate the affect of climate change, advanced physiological and biochemical parameters be identified so as to develop climate resilient sugarcane genotypes.
- Entrepreneurship development and capacity building programmes be carried out for operating and maintenance of the sugarcane machines.
- Value addition in jaggery products be promoted.
- App based Advisory System should be developed and tried for the popularization of the technology.

Institute Research Council Meeting

The Institute Research Council (IRC) meeting of the ICAR-Indian Institute of Sugarcane Research (IISR), Lucknow was held under the chairmanship of Dr. A.D. Pathak, Director of the Institute during July 2-5, 2019 to review and discuss the on-going research projects on sugarcane in the Institute. Fifty six scientists and five technical officers of the Institute participated and discussed the research findings of 67 ongoing-Institute research projects, and the technical programme for the next year. Following new research project proposals/ concept notes were approved:

- Nano-urea to improve nitrogen use efficiency in sugarcane
- Development of small powder jaggery cubes
- Design and development of IISR model jaggery unit for enhancing capacity
- Efficiency of designs in sugarcane field experiments (RCBD vs Alpha design)
- Development of district-level database on sugarcane growth and sustainability

IMC Meeting

Forty sixth meeting of Institute Management Committee (IMC) was held under the chairmanship of Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow on July 20, 2019. Progress of R & D efforts was reviewed and various administrative matters were discussed in the meeting.

Review of DBT-ATL Project

Dr. Anupam Varma, Chairman, PA visited IISR on October 28, 2019 to review DBT sponsored Accredited Test Laboratory (ATL) established under National Certification System of Tissue Culture-raised Plants (NCS-TCP) at IISR. Prof. Varma held a discussion with the Director, IISR, while the Coordinator of the project Dr. Sanjeev Kumar, Principal Scientist (Biotechnology) and Dr. Dinesh Singh, PIs facilitated the technical audit. Prof. Varma scrutinized all the records including job cards, test reports, quality certificates, equipment purchased under the project including its financial status, *etc*., and showed satisfaction over the functioning and execution of this project.

Zonal Monitoring Teams of AICRP(S)

The five zonal monitoring teams were constituted for monitoring the AICRP(S) trials conducted at different centres under different agro-climatic zones. The monitoring teams visited in respective zones and monitored the activities of the centres. After completion of monitoring work, the team leader of the monitoring team submitted the detailed report to the Project Coordinator (S) and the report discussed during Annual Workshop/Group Meeting of the AICRP on Sugarcane. Besides these, the following regular/voluntary centres of AICRP on Sugarcane were monitored and evaluated by Dr. A.D. Pathak, Director and the Project Coordinator (Sugarcane):

- All India Coordinated Research Project on Sugarcane Centre at RSJRS, Kolhapur on August 21, 2019
- Regional Research Station, Uchani (AICRPs centre) for monitoring of experiments and interaction between the scientific staff handling various experiments on August 9, 2019
- AICRP(S) Centre at ARS, Sankeshwar and discussed with the Head and Scientists of Sankeshwar centre
- S. Nijalingappa Sugar Institute, Belagavi centre on August 23, 2019.
- Dr S.K. Shukla, visited and monitored at IISR Regional Centre, Motipur and IIFSR, Modipuram during May 12-15, 2019.


RRS, Uchani


ARS, Sankeshwar


RS&JRS, Kolhapur


SNSI, Belagavi

CHAPTER 18

Participation in Conferences/Workshops/Seminar/Symposia

Name	Name of the Seminar / Symposia / Meeting	Venue	Date
Drs. A.K. Sharma and Rakesh Kumar Singh	Conference on SVAHE 2019	GBPUA&T, Pantnagar	April 02-04, 2019
Drs. PK Singh and Sanjeev Kumar	Joint AGM of AICRP-NSP (Crops) and ICAR Seed Project for the year 2018-19	CCSHAU, Hisar	April 07-09, 2019
Dr. A.D. Pathak, all Scientists, Sh. Brahm Prakash and Dr. Anita Sawnani	25th Meeting of RAC of ICAR-IISR, Lucknow	ICAR-IISR, Lucknow	May 02-03, 2019
Dr. A.D. Pathak	First Meeting of Core Committee on Preparation of Policy Document on Futuristic Crop Planning for 2030-2050	NASC Complex, New Delhi	May 14-15, 2019
Drs. P.K. Singh and Sangeeta Srivastava	*Hindi Karyashala*	ICAR-IISR, Lucknow	May 20, 2019
Dr. Anil Kumar Singh	Seminar on Agricultural Technology Innovation for South Asian Countries	China	May 27-June 04, 2019
Dr. P.K. Singh	Meeting of 'Doubling Farmer's Income' with Representatives of DSCL Group	ICAR-IISR, Lucknow	May 28, 2019
Drs. Rajesh Kumar, Sangeeta Srivastava, Dinesh Singh, R.S. Dohare, Sukhbir Singh, Ram Ratan Verma and Rajeev Kumar	NISSTA Annual Convention and Sugar Expo-2019 on "Major Challenges for Indian Sugar Industry"	National Sugar Institute, Kanpur	May 29-30, 2019
Dr. A.D. Pathak	Meeting of Screening Committee of SDF for Considering Loan Applications of Sugar Factories for Cane Development	Krishi Bhawan, New Delhi	May 31, 2019
Dr. A.D. Pathak	SDF Meeting	Krishi Bhawan, New Delhi	June 5, 2019
Drs. Mrityunjai Kumar Singh, Dilip Kumar and Shri Rajiv Ranjan Rai	*Gur Mahotsav*- 2019	Muzaffarnagar (U.P.)	June 08-10, 2019
All Scientists and Technical Personnel	UPAAS 30th Foundation Day & Seminar on Priorities and Strategies to Boost Farmers' Income	ICAR-IISR, Lucknow	June 14, 2019
Drs. A.D. Pathak, all Scientists and Technical Personnel	National Workshop-cum-Brainstorming Session on Enhancing Productivity & Farmers' Income through Sustainable Sugarcane Production Technologies organized by NEEDEF and IISR	ICAR-IISR, Lucknow	June 20, 2019

Name	Name of the Seminar / Symposia / Meeting	Venue	Date
Drs. A.D. Pathak, all HoDs, I/c Sections, Dr. Sangeeta Srivastava and Senior Administrative Officer	46th Institute Management Committee Meeting of ICAR-IISR, Lucknow	ICAR-IISR, Lucknow	June 22, 2019
Dr. T.K. Srivastava	Interface Meeting on 'Enhancing the Preparedness for Agricultural Contingencies during *Kharif* 2019' organized by CRIDA, Hyderabad	Krishi Bhawan, Lucknow	June 24, 2019
Dr. A.K. Sharma	CACP Meeting on Price Policy for Sugarcane 2021-22 Sugar Season	Krishi Bhavan, New Delhi	June 24-25, 2019
Dr. Rajendra Gupta	49th Annual Convention of SISSTA	Chennai	June 28-29, 2019
Dr. A.D. Pathak, All Scientists, Sh. Brahm Prakash, Dr. Anita Sawnani, Dr. Prashant Vikram and Sh. Ashish Singh Yadav	IRC Meeting	ICAR-IISR, Lucknow	July 02-05, 2019
Dr. M.R. Singh	28th Annual Group Meeting on AICRP on Biological Control of Crop Pests	AAU, Anand, Gujarat	July 05-09, 2019
Dr. Akhilesh Kumar Dubey	36th Zonal Workshop of KVKs of Zone-III, Kanpur	Narendra Dev University of Agriculture and Technology, Ayodhya	July 8-9, 2010
Dr. A.D. Pathak	ICAR Foundation Day and Award Ceremony	NASC Complex, New Delhi	July 16, 2019
Dr. A.D. Pathak	Director's Meeting	NASC Complex, New Delhi	July 17, 2019
Drs. Sangeeta Srivastava, Rajesh Kumar, Rajendra Gupta and S.N. Singh	77th Annual Convention of STAI & International Sugar Expo- 2019	Biswa Bangla Convention Centre, Kolkata	July 17-19, 2019
Dr. Amaresh Chandra	5th International Conference on ABS 2019	Macau, China	July 21-24, 2019
Dr. Sangeeta Srivastava	National Workshop on Bioinformatics in Agriculture	NAARM, Hyderabad	July 25-28, 2019
Dr. A.D. Pathak and Dr. A.P. Dwivedi	Zonal Workshop of KVKs of M.P. & Chattishgarh	KVK- Chhattarpur, Khajuraho	July 26-30, 2019
Dr. M. Swapna	30th ISSCT Congress	Tacuman, Argentina	September 01-05, 2019
Dr. A.D. Pathak	54th Meeting of Board of Management	ICAR-IVRI, Izatnagar	September 6, 2019
Dr. A.D. Pathak, All Scientists and Staff	"*Swakshata hi sewa*" programme	ICAR-IISR, Lucknow	September 11, 2019
Dr. Sanjeev Kumar	8th Training Workshop for the Institutional Biosafety Officers & Scientists	KAB, Pusa, New Delhi	September 19-21, 2019
Dr. P.K. Singh	*Hindi Karyashala*	ICAR-IISR, Lucknow	September 24, 2019
Dr. T.K. Srivastava	Brain Storming Session on 'Climate Smart Agriculture with special reference to Uttar Pradesh' organized by UP Department of Agriculture	Lucknow.	September 25, 2019

Name	Name of the Seminar / Symposia / Meeting	Venue	Date
Drs. Veenika Singh and Viveka Nand Singh	Workshop on "Rooftop Gardening of Horticultural Crops"	ICAR-CISH, Lucknow	September 26, 2019
Dr. M. Swapna	National Seminar on Indian Sugar-Standardization and Quality Considerations	NSI, Kanpur	September 26, 2019
Dr. P.K. Singh	16th DUS Review Meeting	NASC Complex, New Delhi	September 26-27, 2019
Dr. A.D. Pathak, Dr. L.S. Gangwar, Dr. A.K. Sah	DCM Shriram Sugar Sustainability Partnership Summit 2019	Hotel Holiday Inn, Aerocity, New Delhi	September 27, 2019
Dr. T.K. Srivastava	State Level Consultation on 'Climate Resilient Agriculture towards Food and Nutritional Security and Sustainable Agricultural Livelihood for the State of UP' organized by World Vision India	ICAR-IISR, Lucknow	September 30, 2019
Dr. L.S. Gangwar	65th Annual Convention of DSTA	Hyatt Regency, Pune	October 1-2, 2019
Drs. Rajesh Kumar, A.K. Sharma and Sukhbir Singh	Seminar on "Sustainable Cane Development and Marketing in Sub-tropical Region"	The Avadh Sugar and Energy Limited, Hargaon, Sitapur	October 11, 2019
Drs. V.K. Singh, Rajesh Kumar Singh, S/Shri Akhilesh Kumar Singh and Abhishek Kumar Singh	International Conference on Sustainable Agriculture Development in Changing Global Scenario	Banaras Hindu University, Varanasi	October 11-13, 2019
Dr. A.K. Sah	Executive Committee Meeting of ISEE	NASC, New Delhi	October 12, 2019
Drs. Rajendra Gupta and Sukhbir Singh,	8th Asian Australasian Conference on Precision Agriculture	PAU, Ludhiana, Punjab	October 13-17, 2019
Drs. A.D. Pathak, S.K. Shukla, M.R. Singh, Rajesh Kumar, T.K. Srivastava, S.N. Sushil, Arun Baitha, A.K. Singh, K.K. Singh, M.K. Tripathi, P.K. Singh, Sanjeev Kumar, Dinesh Singh, Chandra Gupta, Syed Sarfaraz Hasan, A.P. Dwivedi, V.P. Jaiswal, A.K. Mall, Ram Ratan Verma, S.K. Holkar, Lalan Sharma, C.K. Gupta, Sanjay Kumar Yadav, S.K. Awasthi, Gaya Karan Singh, Adil Zubair and Avadhesh Kumar Yadav	33rd Annual Group Meeting of All India Coordinated Research Project on Sugarcane	UAS, Dharwad	October 14-16, 2019
Drs. Rajendra Gupta and Sukhbir Singh	8th Asian-Australasian Conference on Precision Agriculture	PAU, Ludhiana	October 14-17, 2019
Sh. Saroj Kumar Singh	Workshop on FMS	ICAR-IASRI, New Delhi	October 15, 2019

Name	Name of the Seminar / Symposia / Meeting	Venue	Date
Dr. Niranjan Lal	12th Scientific Advisory Meeting of KVK, Jamnabad Farm, Lakhimpur Kheri	Committee DTO Office, Lakhimpur Kheri	October 18, 2019
Sh. Ashish Singh Yadav	Training cum workshop on J-Gate @ CeRA for Northern Region	NASC Complex, New Delhi	October 23, 2019
All Scientists and Technical Personnel	Farm Machinery Entrepreneurship Workshop and Expo organized by CARD	ICAR-IISR, Lucknow	October 24, 2019
Dr. S.N. Singh	Mechanization and *Kisan Samriddhi Mela*	Balrampur Chini Mills, Unit-Haidergarh	October 25, 2019
Dr. A.D. Pathak	Review Meeting for Finalization of Recommendation of AICRP Review Committee	Krishi Bhawan, New Delhi	October 29, 2019
Dr. Rajesh Kumar	Training Workshop for "Vigilance Officers of ICAR"	ICAR-NAARM, Hyderabad	October 29-November 02, 2019
Dr. Chandra Gupta	XIII World Aqua Congress, 2019	India Habitat Centre, New Delhi	October 30-31, 2019
Drs. Akhilesh Kumar Dubey and Niranjan Lal	Mid Term Workshop & Action Plan of next year (2020-21)	ICAR-ATARI, Kanpur	November 05-06, 2019
Dr. Sukhbir Singh	National Seminar on Need for Forward Looking Development Strategies for India	B.S.N.V. Post Graduate College (K.K.V.) Lucknow	November 5-6, 2019
Drs. Chandra Gupta, Kamta Prasad and R.R. Verma	Golden Jubilee International Conference on New Millennia Agriculture- Novel Trend and Future Scenario "GINMA-2019"	CCS Haryana Agricultural University, Hisar (Haryana)	November 6-8, 2019
Sh. Ranjit Singh Gujjar	National Conference on Integrative Plant Biochemistry and Biotechnology	ICAR-IIRR, Hyderabad	November 8-9, 2019
Dr. Amaresh Chandra and Sh. Ranjit Singh Gujjar	Workshop on Gene Editing for Enhancing Plant Productivity and Stress Tolerance	ICAR-IIRR, Hyderabad	November 10-12, 2019
Drs. Sharmla Roy, S.N. Sushil, V.P. Jaiswal, Deeksha Joshi and Lalan Sharma	XIX International Plant Protection Congress (IPPC 2019) on Crop Protection to Outsmart Climate Change for Food Security and Environmental Conservation	ICRISAT, Hyderabad	November 10-14, 2019
Drs. A.D. Pathak, A.K. Sharma, Sangeeta Srivastava, Radha Jain	National Conference on Sugarcane-Is there any alternative?	ICAR-IISR, Lucknow	November 11, 2019
All Scientists and Technical Personnel	National Workshop on 'Sugarcane: Challenges & Future Strategies for Doubling Farmer's Income' organized by Directorate of Sugarcane Development. GoI and ICAR-IISR, Lucknow	ICAR-IISR, Lucknow	November 14, 2019
Dr. Sanjeev Kumar	National Conference on Emerging innovations in Agriculture, Biotechnology and Health Sciences	B.N. College of Engineering and Technology, Lucknow.	November 14, 2019
Dr. Akhilesh Kumar Dubey and Dr. Deepak Rai	Meeting of Quinquennial Review Team	ICAR-ATARI, Kanpur	November 15-16, 2019

Name	Name of the Seminar / Symposia / Meeting	Venue	Date
Drs. S.R. Singh and R.R. Verma	84th Annual Convention of Indian Society of Soil Science and National Seminar on Development in Soil Science: 2019	Banaras Hindu University, Varanasi	November 15-18, 2019
Dr. A.P. Dwivedi	International Conference on Advances in Agriculture under Changing Climate Scenario for Sustainable Global Development	University of Allahabad, Prayajraj	November 16-17 2019
Dr. Niranjan Lal	National Seminar on Socio-Digital Approaches for Technologies of Indian Agriculture	CCSHAU, Hisar	November 19-22, 2019
Dr. Mona Nagargade	3rd International Conference on Nanobiotechnology for Agriculture – NANOFORAGRI 2019	Exhibition Ground, Aerocity, New Delhi	November 21-22, 2019
Dr. L.S. Gangwar	79th Annual Conference of Indian Society of Agricultural Economics	IGKVV, Raipur	November 21-23, 2019
Sh. Ashish Singh Yadav	International Conference on Empowering Libraries with Emerging Technologies for Common Sustainable Future	Babasaheb Bhimrao Ambedkar University, Lucknow	November 22-24, 2019
Director, All the Scientists and Staff	Celebration of Constitution Day and Citizen's Duties	ICAR-IISR, Lucknow	November 26, 2019
Dr. M.K. Singh	Annual Workshop of AICRP on FIM	CCSHAU, Hisar	December 4-6, 2019
Dr. A.K. Singh	Workshop on crop residue management and soil health improvement	Krishi Bhavan, Lucknow	December 5, 2019
Drs. Barsati Lal, V.P. Jaiswal, Akhilesh Kumar Dubey, Dr. Veenika Singh and Viveka Nand Singh	Seminar on "Progressive Horticulture Conclave-2019" on Futuristic Technologies in Horticulture	ICAR-IISR, Lucknow	December 8-10, 2019
Dr. A.K. Sharma and Mr. Ram Lakhan Shakya	4th National Workshop of Officer In charge, Data Management (ICAR Research Data Repository for Knowledge Management)	NASC Complex, Pusa, New Delhi	December 10-11, 2019
Dr. Deepak Rai	Trainers Training Programme under Agriculture Skill Council of India (ASCI)	ICAR-ATARI, Kanpur	December 10-12, 2019
Dr. Y.E. Thorat	National Symposium on Nematodes: A Threat to Food Security and Farmer's Livelihood	Manipur University, Imphal	December 11-13, 2019
Dr. M.R. Singh	Workshop on Agriculture for Regional Plan 2041	Scope Conventional Centre, New Delhi	December 16, 2019
Dr. L.S. Gangwar	27th AERA Conference	PAU, Ludhiana	December 17-19, 2019
Drs. A.D. Pathak, M.K. Tripathi and A.K. Mall	Meeting with Officers of Sugarcane Industries Department, Govt. of Bihar	Patna	December 19, 2019
Dr. Sangeeta Srivastava	10th International Conference on Agriculture, Horti and Food Sciences ICAHFS-2019	New Delhi	December 21-22, 2019

CHAPTER 19

Events Organized

National Workshop on Sugarcane: Challenges & Future Strategies for Doubling Farmers' Income

A National Workshop on Sugarcane: Challenges & Future Strategies for Doubling Farmers' Income was organized at the ICAR-IISR, Lucknow in collaboration with Directorate of Sugarcane Development, Department of Agricultural Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Govt. of India at ICAR-IISR, Lucknow on November 14, 2019.

Conference on Sugarcane-Is there any Alternative? organized

One-day Conference on Sugarcane-Is there any Alternative?" was organized at ICAR-IISR, Lucknow on November 11, 2019 with the collaboration of National Rainfed Area Authority (NRAA) and Global AgriSystem. The prospects of Sugar beet cultivation in India were discussed in the Conference. A presentation on the techno-economic feasibility of sugarbeet cultivation in India was made by Dr. A.K. Sharma, Principal Scientist (Agricultural Economics).

National Workshop cum Brainstorming Session organized

A National Workshop cum Brainstorming Session on Enhancing Productivity and Farmers Income through Sustainable Sugarcane Production Technologies was organized at the Institute on June 20, 2019 by National Education Employment & Development Foundation (NEEDEF), Gorakhpur and ICAR-Indian Institute of Sugarcane Research, Lucknow. Dr. A.K. Singh, Deputy Director General (Agricultural Extension) was the Chief Guest on the occasion. Dr. Gurbachan Singh, Ex-Chairman, Agricultural Scientists Recruitment Board, New Delhi was the Guest of the Honour. More than 250 participants from different parts of the country participated in the National Workshop. To mark the occasion, Dr. A.K. Singh delivered First Foundation Day Lecture on the first Foundation Day of NEEDEF.

150th Birth Anniversary of Mahatma Gandhi celebrated

The 150th Birth Anniversary of Mahatma Gandhi was celebrated at the Institute during September 26, 2019 to October 2, 2019. The main activities organized during the week long celebrations were as follows:

- Sensitization about the programme for the week through banners & posters display and as messages in whattsapp groups involving farmers, researchers and extension and state line department personnel.
- *Kavi Sammalen* during *Hindi Pakhwara* was organized to highlight the significance of the teaching of Mahatma Gandhi.

- Signing of MoU with Sugar Industry (DSCL) for intensive transfer of technology, demonstrations and scientists visits and participatory research and development by adopting villages in Central Uttar Pradesh region
- Competitions on Essay writing in Hindi on Gandhi's thought on agriculture and allied sectors, and also on quote/slogan writing.
- A show of documentary films on Mahatma Gandhi's life in relation to agriculture and allied sectors/rural sanitation was organised in the Institute.

- Sensitization programme in two IISR adopted villages
- Lecture on Relevance of Mahatma Gandhi's Vision on Agriculture and Allied Sector Development in 21st Century" by Prof Usha Bajpai, Ex. Professor & Head, Centre of Excellence in Renewable Energy Education and Research, Lucknow University

- Garlanding of /flower tribute to Mahatma Portrait and *Swachchhta* procession was organised on October 2, 2019
- Lecture/Message on Mahatma Gandhi's Vision on Agriculture and Rural Development
- Prize distribution function for the winners of competitions and press releases
- *Shramdaan* under *Swatchhta Hi Seva* programme on October 2, 2019

Vigilance Awareness Week-2019

The Vigilance Awareness Week-2019 was observed at the Institute on October 28, 2019 to November 2, 2019. The CVC declared theme of this year was Integrity- A way of life. Various activities organized during the week long celebrations were as follows:

- A message on the importance of observance of Vigilance Awareness Week 2019 was delivered by Dr. A.D. Pathak, Director of the Institute.

- Banners and posters to make the staff and the visiting stakeholders and public aware and sensitize them about the importance of vigilance awareness were prepared and displayed at the Institute Premises including IISR entry gates, SBI branch, Bank ATM outlet, Canteen, Ikshupuri residential colony, and in Institute boundary walls facing busy Rae bareli Road. Special posters depicting the Integrity Pledge were prepared and displayed in all the notice boards/Standees in all the Divisions/KVKs
- An Essay writing competition on the topic: Integrity- a way of life was organized at the Institute. Staff representing different functional groups participated in the essay competition. Winners were appreciated by distributing prizes and certificates.

- An Integrity Pledge & Unity cum integrity run was undertaken by the Institute staff, and the oath was administered by Dr.M.R.Singh, Head, Division of Crop Protection.

- Closing session of Vigilance Awareness Week-2019 was observed by focusing on the importance of each activity carried out during the week long period. A lecture on "Preventive Vigilance-a Management Tool for Good Governance" was delivered by Mr. S.K. Singh, SAO, ICAR-IISR, Lucknow who highlighted the nature and scope of preventive vigilance and also provided a list of about 20 case studies in ICAR system where vigilance was required. Dr. A.D. Pathak, Director of the Institute emphasized the need for developing a system of preventive vigilance in the Institute, and the need for taking stock of the situation periodically in this session. Coordinator of the programme, Dr. A.K. Sharma highlighted four habits that may help us to live with integrity and extended the vote of thanks.

Celebration of Constitution Day/Year

The Constitution Day was celebrated at the Institute on November 26, 2019 and number of subsequent activities were undertaken to mark the year for the next one year till November 26, 2020 are to be observed in the Institute. The highlights of the celebrations were the awareness creation on fundamental duties through banners, posters and pamphlets, and the dissemination of public messages on fundamental duties in Institute website. A special assembly of all the staff was organized and the Preamble on the Constitution was read in the Assembly. A pledge on sincerely fulfilling all the 11 Fundamental Duties was also undertaken by the staff members.

Hindi Workshops Organized

- A Hindi Workshop was organized on Stress Management at the ICAR-IISR, Lucknow on May 20, 2019. All the staff of the Institute participated in the Workshop. In this Workshop, Shri V.N. Tiwari, Retired Hindi Officer, CSIR-CDRI, Lucknow delivered a lecture on stress management.
- A Hindi Workshop was organized on Cleanliness and Environmental Conservation (*Chalo Banaein Mangal Parivar)* was organized at the ICAR-IISR, Lucknow on September 24, 2019. Forty six participants attended the Workshop. In this Workshop, Shri Brijendra Pal Singh, National Organization Secretary, Lok Bharati, Lucknow also delivered a lecture.
- A Hindi Workshop was organized at the Institute on December 21, 2019 on *"Hindi Vartanee Ka Mankeekaran"* which was attended by 43 trainees of this Workshop. Dr. Harishankar Misra, Ex. Professor, Department of Hindi, University of Lucknow, Lucknow delivered a lecture on the theme of the Workshop.

Rajbhasha Fortnight Organized

Rajbhasha Fortnight was organized at the Institute during September 14-30, 2019. The fortnight was initiated by a lecture on Thoughts of the Father of the Nation, Mahatma Gandhi on *Rajbhasha*. Various competitions like Hindi Typing in Unicode, Essay Writing, Powerpoint Presentation of the Research Achievements of the Institute, *Antakshari*, Noting, Writing of Office Orders/MoU, Question Answer on General Knowledge of Hindi, *Ashubhashan* and Review of Work Done during the Last Year etc., were organized during the fortnight. More than 200 staff of the Institute participated in the above mentioned competitions. An All India *Kavi Sammelan* was also organized during the fortnight on September 26, 2019. Eight renowned poets

viz., Shri Ram Kishore Tiwari, Shri Shambhu Shikhar, Smt. Roopa Pandey 'Satroopa', Shri Farookh Saral, Shri Santosh Dikshit, Shri Asheesh Jhatpatee, Sh. Pramod Pankaj and Dr. Sudhir Kumar Shukla recited their poems. On September 28, 2019, 89 winners of various competitions were awarded the first, second, third and consolation prizes and Certificates by the Chief Guest in the Prize Distribution Ceremony.

On this occasion, a special lecture on *Rajbhasha* and Sanskrit was delivered by Shri Sohan Lal Ukeel, Member, Uttar Pradesh Council of Secondary Sanskrit Education. Shri Ukeel urged the participants that we should be proud of our language and use minimum

words of English in our day-to-day Hindi conversation. He termed Sanskrit as the mother of all the languages. A Consolidated Report on various achievements made at the Institute in *Rajbhasha* was presented by Dr. A.K. Sah, Principal Scientist and Incharge, *Rajbhasha* Cell.

Meetings of District *Rajbhasha* Implementation Committee (Office-3) organized

ICAR-IISR, Lucknow is the chairman office of District Rajbhasha Implementation Committee (Office-3). At present, there are 70 offices of Cental Government located in Lucknow for evaluation of work related with *Rajbhasha*. Two meetings of the year 2019 were organized under the chairmanship of Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow and Chairman, District *Rajbhasha* Implementation Committee in which the Heads of the Member Offices and Hindi Officers participated in the meeting.

- First half yearly meeting of District *Rajbhasha* Implementation Committee (Office-3) for the year 2019 was organized on June 25, 2019.

- Second half yearly meeting of District *Rajbhasha* Implementation Committee (Office-3) for the year 2019 was organized on November 26, 2019. The Offices of DRM, Northern Railway, Lucknow; CSIR-IITR, Lucknow and the office of DRM, North Eastern Railway, Lucknow were awarded first, second and third prize, respectively for the excellent work done in *Rajbhasha*. ICAR-NBFGR. Lucknow; CSIR-IITR, Lucknow; DRM, Northern Railway, Lucknow and CSIR-CIMAP, Lucknow were awarded first, second, third and fourth, respectively for their *Rajbhasha* magazines.

Tree plantation drive at IISR campus

A tree plantation drive was launched on July 23, 2019 at ICAR-IISR, Lucknow. On this occasion, the Chief Guest, Dr. Sushil Solomon, Vice-Chancellor, CSAUA&T, Kanpur emphasized on the importance of environmental conservation. Dr. A.D. Pathak, Director

urged all the Scietists and other officials to motivate their family members and general public to plant saplings at their individual level, which will be a significant contribution from us towards green environment. During the month long plantation drive, about 1,000 plants were planted in the Institute campus. Plantation was also done in the schools located in the eight Institute adopted villages.

Independence Day Celebrated

The 73rd Independence Day was celebrated at ICAR-IISR, Lucknow on August 15, 2019 with pride, great fervor and enthusiasm. At the outset, Dr. A.D. Pathak, Director of the Institute along with Heads of the Divisions offered floral tributes to Father of the Nation, Mahatma Gandhi. The Indian Flag was hoisted by Dr. A.D. Pathak which was followed by recitationof the National Anthem by all the staff of the Institute. Dr. Pathak in his message, remembered the contributions of the brave freedom fighters who sacrificed their lives for the freedom of our country and urged to take pledge to carry out the assigned duties with full sincerity, devotion and dedication for enhancement of sugarcane production, productivity, profitability and sustainability to meet future sugar and energy requirement of India.

Awareness programme on *Parthenium* eradication organised

KVK, ICAR-IISR, Lucknow organized an awareness programme on *Parthenium* eradication to create awareness among the farmers and general public about the hazardous effect of *Parthenium* weed on August 22, 2019.Awareness programme was initiated by Dr. M.R. Singh, Head, Division of Crop Protection who highlighted that this weed was visible in India first time during 1955 and has now covered more than 35 million hectare area in the country and causing Eczema, Allergy and Fever in human beings. The consumption of this weed in animals causes swelling in its mouth and causes a pungent smell in the milk of lactating animals.Plants of this weed should be uprooted before the rainy season

before its flowering and be used for making compost (organic manure). He further added that the compost made by Parthenium is better than the compost made by cattle dung due to high plant nutrients value. He also advised to release Mexican beetles (A bio-control agent) to eradicate this weed. Dr. S.N. Singh, Principal Scientist and Coordinator, KVK, IISR informed that parthenium which is locally known as *Gazar Ghas, Congress Ghas, Chatak Chandni* and *Kadwi Ghas* is responsible for health problems in human beings and animals, besides deteriorating environment, loss of productivity and biodiversity. Dr. A.K. Dubey, Head, KVK, IISR, Lucknow said that Parthenium has the leaves like the carrot crop and produces hundreds of tiny white flowers. Due to the completion of its life cycle in 3-4 months, 3-4 generations of this weed can be completed in a year. In non-farming areas, it can be controlled by spraying of Glyphosate weedicide @ 10 ml per litre of water or Metribuzyn @ 3.0 – 3.5 ml per litre of water. For managing this weed in the crops, the farmers are advised to consult the Scientists to use the appropriate weedicide. He suggested that this weed can only be eradicated by community participation.

International Yoga Day observed

International Yoga Day was celebrated at ICAR-IISR, Lucknow with great fervour and enthusiasm on June 21, 2019. The participants performed various *Asanas* followed by *Omkar* chanting. The importance of the *Asanas* was also explained simultaneously. On this

occasion, Dr. A.D. Pathak, Director encouraged students to practice regular yoga to remain fit and improve concentration. He highlighted that the regular practice of yoga will surely help in achieving a better life, physically, mentally and spiritually. He also highlighted that the yoga is more than a physical exercise. In Indian traditions, it has a meditative and spiritual core.

Swachhta Hi Seva Programme Celebrated

ICAR-IISR, Lucknow celebrated *Swachhta Hi Seva* Programme during September 11-October 2, 2019. IISR, Lucknow. IISR, Lucknow along with its KVKs located at Lucknow and Lakhimpur Kheri took active part in the *Swachhta* activities and conducted a wide range of activities which included organising cleaning of public places, community market places and/or nearby tourist/ selected spots. The plastic material spilled on the road

side were lifted and dumped into the municipality bins. Large number of people were apprised the importance of cleanliness and plastic free environment. The people were informed that although plastic bags have become an integral part and a natural choice of everyone's life due to its multi purpose usage, its convenience comes with significant drawbacks and one of its biggest shortcoming is the pollution which is creating havoc on the planet globally. Plastic bags are non biodegradable and have become a massive threat to our ecosystem as they take hundreds of years to decompose and have started affecting the biodiversity of a planet. The people were requested to pick up plastic litter in the surroundings as the plastic makes a soil infertile and affect vegetative growth. Message of cultivating eco-friendly habits and say no to plastics were conveyed in nearby villages.

CHAPTER 20

Distinguished Visitors

Name and Designation	Date of visit
Prof. N.P. Singh, Director, ICAR-National Institute of Abiotic Stress Management, Baramati, Pune	June 12-15, 2019
Shri Surya Pratap Shahi, Hon'ble Minister of Agriculture, Agriculture Education and Agriculture Research, Govt. of Uttar Pradesh	June 14, 2019
Sh. Ranvendra Pratap Singh (Dhunni Singh), Hon'ble Minister of State for Agriculture, Agriculture Education and Agriculture Research, Govt. of Uttar Pradesh	June 14, 2019
Dr. Panjab Singh, Ex. Secretary, DARE & DG, ICAR	June 14, 2019
Dr. Gaya Prasad, VC, Sardar Patel University of Agric. & Tech., Meerut	June 14, 2019 and December 7, 2019
Dr. Shankar Lal, Ex. Director, ICAR-IIPR, Kanpur	June 14, 2019
Dr. B. Singh, DG, UPCAR, Lucknow	June 14, 2019
Dr. R.C. Srivastava, VC, Dr. Rajendra Prasad CAU, Pusa	June 14, 2019
Dr. R.K. Singh, Director, ICAR-IVRI, Izatnagar	June 14, 2019
Dr. S.K. Chaturvedi, Dean, RLB CAU, Jhansi	June 14, 2019
Dr. Gurbachan Singh, Ex. Chairman, ASRB, New Delhi	June 20, 2019
Dr. A.K. Singh, DDG (Ext.), ICAR & Director, ICAR-IARI, New Delhi	June 20, 2019 and August 31, 2019
Dr. B.N. Singh, Ex. Director, ICAR-CRRI, Cuttack	June 20, 2019
Dr. G.P. Singh, Director, ICAR- IWBRI, Karnal	June 20, 2019
Dr. R.K. Singh, Ex. Director (Research), NDUA&T, Ayodhya	June 20, 2019
Dr. Basant Ram, Ex. VC, NDUA&T, Ayodhya	June 14 and 20, 2019
Dr. R.K. Singh, Assistant Director General (CC), ICAR, New Delhi	June 22, 2019 and November 14, 2019
Dr. U.S. Gautam, Vice Chancellor, Banda University of Agriculture and Technology, Banda	June 25, 2019
Shri Lakhan Singh Rajput, Hon'ble State Minister of Agriculture, Govt. of Uttar Pradesh	October 24, 2020
Shri Anees Ansari, Ex APC, Govt. of Uttar Pradesh and Chairman, CARD	October 24, 2020
Shri Alok Ranjan, Ex Chief Secretary, Govt. of Uttar Pradesh	October 24, 2020
Sh. S. Bhoosreddy, Cane Commissioner, Govt. of UP, Lucknow	November 14, 2019
Mrs. Shubha Thakur, Joint Secretary, DAC & FW, MOA & FW, Govt. of India, New Delhi	November 14, 2019
Dr. J. Singh, Director, UPCSR, Shahjahanpur	November 14 and 22, 2019
Dr. Man Singh, Director, Directorate of Sugarcane Development, DAC & FW, Lucknow	November 14, 2019
Mr. R.L. Tamak, Executive Director, DCM Shriram Ltd, New Delhi	November 14, 2019
Dr. S. Rajan, Director, ICAR-CISH, Lucknow	December 8, 2019
Dr. Mangala Rai, Ex. Secretery, DARE and Ex. DG, ICAR, New Delhi	December 11, 2019
Dr. M.P. Pandey, Ex. Vice Chancellor, IGKVV, Raipur	December 26, 2019
Dr. Pradip Dey, ICAR-IISS, Bhopal	December 26, 2019

CHAPTER 21

Personnel

(As on December 31, 2019)

Director	:	Dr. A.D. Pathak
Crop Improvement		
Principal Scientist & Head	:	Dr. D.R. Malaviya
Principal Scientist (Plant Breeding)	:	Dr. Jyotsnendra Singh (On Deputation)
	:	Dr. P.K. Singh
	:	Dr. Sanjeev Kumar
Principal Scientist (Genetics & Cytogenetics)	:	Dr. Sangeeta Srivastava
Principal Scientist (Genetics)	:	Dr. M. Swapna
Principal Scientist (Agril. Biotechnology)	:	Dr. Sanjeev Kumar
Senior Scientist (Plant Breeding)	:	Dr. Ashutosh Kumar Mall
Scientist (SS) (Agricultural Biotechnology)	:	Sh. Ranjit Singh Gujjar
Senior Technical Officer	:	Mr. Raghvendra Kumar
	:	Dr. Ram Kishor
Crop Production		
Principal Scientist & Head	:	Dr. S.K. Shukla
Principal Scientist (Agronomy)	:	Dr. V.P. Singh
		Dr. T.K. Srivastava
	:	Dr. S.N. Singh
	:	Dr. A.K. Singh
	:	Dr. K.K. Singh
	:	Dr. Chandra Gupta
	:	Dr. M.K. Tripathi
	:	Dr. V.K. Singh
	:	Dr. A.P. Dwivedi
Principal Scientist (Soil Science)	:	Dr. S. R. Singh
Principal Scientist (Agril. Extension)	:	Dr. R.S. Dohare
Senior Scientist (Agronomy)	:	Dr. V.P. Jaiswal
Scientist SS (Soil Science)	:	Dr. Ram Ratan Verma
Scientist (Agronomy)	:	Dr. Dilip Kumar
	:	Dr. Mona Nagargade
Assistant Chief Technical Officer	:	Mrs. Asha Gaur
	:	Dr. R.K. Singh
Senior Technical Officer	:	Mr. S.N. Srivastava
Technical Officer	:	Mr. Anil Kumar Singh
	:	Mr. Sanjay Gautam
Crop Protection		
Principal Scientist & Head	:	Dr. M.R. Singh
Principal Scientist (Agril. Entomology)	:	Dr. A.K. Jaiswal
	:	Dr. Sharmila Roy
	:	Dr. S.N. Sushil
	:	Dr. Arun Baitha
Principal Scientist (Plant Pathology)	:	Dr. Dinesh Singh

Sr. Scientist (Plant Pathology)	:	Dr. Deeksha Joshi
Chief Technical Officer	:	Dr. D.C. Rajak (On deputation)
Assistant Chief Technical Officer	:	Mr. I.P. Maurya
Senior Technical Officer	:	Mrs. Pramila Lal
Agricultural Engineering		
Principal Scientist & Head	:	Dr. A.K. Singh
Principal Scientist (FMP)	:	Dr. R.D. Singh
	:	Dr. S.I. Anwar
	:	Dr. M.K. Singh
Principal Scientist (SWCE)	:	Dr. Rajendra Gupta
Senior Scientist (FMP)	:	Dr. Sukhbir Singh
Senior Scientist (AS &PE)	:	Dr. Dilip Kumar
Chief Technical Officer	:	Mrs. Mithilesh Tiwari
	:	Mr. M.H. Ansari
Assistant Chief Technical Officer	:	Mr. Suresh Kumar Kushwaha
	:	Mr. Krishna Nand Singh
	:	Mr. Rajiv Ranjan Rai
Senior Technical Officer	:	Mr. Umesh Kumar
Technical Officer	:	Mr. Chaman Singh
	:	Mr. Surya Dev Singh
Plant Physiology & Biochemistry		
Principal Scientist & Head	:	Dr. Radha Jain
Principal Scientist (Biochemistry)	:	Dr. Amaresh Chandra
Principal Scientist (Organic Chemistry)	:	Dr. Pushpa Singh
Principal Scientist (Plant Physiology)	:	Dr. S.P. Singh
Scientist (Plant Physiology)	:	Dr. Chandan Kumar Gupta
Scientist (Biochemistry)	:	Mr. Rajeev Kumar
Assistant Chief Technical Officer	:	Mr. C.P. Singh
	:	Mr. Devender Singh
Technical Officer	:	Mr. R.K. Singh
PME Cell & Institute Technology Management Unit		
Nodal Officer & Incharge	:	Dr. L.S. Gangwar
Chief Technical Officer	:	Mr. Brahm Prakash
Assistant Chief Technical Officer	:	Dr. Anita Sawnani
AKMU		
Principal Scientist & Incharge	:	Dr. Rajesh Kumar
Principal Scientist (Agril. Economics)		Dr. A.K. Sharma
Principal Scientist (Computer Application)	:	Dr. S.S. Hasan
Assistant Chief Technical Officer	:	Mr. Atul Kumar Sachan
Extension & Training Unit		
Principal Scientist & In-Charge	:	Dr. A.K. Sah
Principal Scientist (Agril. Extension)	:	Dr. Barsati Lal
Senior Scientist (Agril. Extension)	:	Dr. Kamta Prasad
Assistant Chief Technical Officer	:	Dr. Om Prakash
	:	Mr. A.K. Singh
Central Lab		
Incharge	:	Dr. V.P. Jaiswal
Assistant Chief Technical Officer		Mrs. Meena Nigam

AICRP on Sugarcane		
Project Coordinator	:	Dr. A.D. Pathak
Principal Scientist (Agronomy)	:	Dr. S.K. Shukla
Principal Scientist (Entomology)	:	Dr. S.N. Sushil
Scientist (Agronomy)	:	Dr. Sanjai Yadav
Scientist (Plant Pathology)	:	Dr. Lalan Sharma
Chief Technical Officer	:	Dr. S.K. Awasthi
	:	Dr. G.K. Singh
Assistant Chief Technical Officer	:	Mr. Adil Zubair
HRD Cell		
Nodal Officer	:	Dr. Sangeeta Srivastava
Co-Nodal Officer	:	Dr. Sukhbir Singh
Farm Section		
Principal Scientist & In-charge	:	Dr. S.K. Shukla
Farm Managar (Chief Technical Officer)	:	Dr. B.B. Joshi
Technical Officer	:	Mr. Deep Kumar
Krishi Vigyan Kendra, Lucknow		
Senior Scientist & I/c	:	Dr. Akhilesh Kumar Dubey
SMS (Home Science)	:	Dr. Veenika Singh
SMS (Plant Protection)	:	Dr. Deepak Rai
SMS (Animal Science)	:	Dr. Rakesh Kumar Singh
SMS (Horticulture)	:	Dr. Viveka Nand Singh
Krishi Vigyan Kendra, Lakhimpur Kheri		
Senior Scientist & I/c	:	Dr. Niranjan Lal
Rajbhasha Prakoshtha		
Principal Scientist & In-charge	:	Dr. A.K. Sah
Technical Officer	:	Mr. Abhishek Kumar Singh
Art & Photography		
Principal Scientist & In-Charge	:	Dr. L.S. Gangwar
Chief Technical Officer	:	Mr. Vipin Dhawan
Assistant Chief Technical Officer	:	Mr. Yogesh Mohan Singh
Senior Technical Officer	:	Mr. Avadhesh Kumar Yadav
Library		
Principal Scientist & In-Charge	:	Dr. (Mrs.) Sharmila Roy
Assistant Chief Technical Officer	:	Mr. Ghanshyam Ram
Senior Technical Officer	:	Mr. R.N.P. Bharti
Other In-Charges		
In-Charge, Seed Production Unit	:	Dr. Sanjeev Kumar
In-Charge, Vehicle	:	Mr. Raj Kumar
In-Charge, Landscaping	:	Mr. Rajiv Ranjan Rai
In-Charge, Guest House	:	Mr. A.K. Sharma
Manager, Guest House	:	Mr. Nag Chand
IISR Regional Centre, Motipur (Bihar)		
Senior Scientist & In-charge	:	Dr. A.K. Mall
IISR Biological Control Centre, Pravarnagar (Maharashtra)		
Nodal Officer	:	Dr. S.N. Singh
Scientist (Plant Pathology)	:	Dr. S.K. Holkar
Scientist (Microbiology)	:	Dr. Deepak Borase
Scientist (Nematology)	:	Mr. Yogesh Kumar Thorat
Administration		
Senior Administrative Officer	:	Mr. Saroj Kumar Singh
Administrative Officer	:	Mr. A.K. Sharma
Finance & Accounts Officer	:	Mr. Raja Ram

Assistant Administrative Officer	:	Mr. R.K. Yadav
	:	Mr. V.P. Tiwari
	:	Mr. Anand Mohan Srivastava
Private Secretary	:	Mr. Rajeev Arora
	:	Mr. Prem Chandra
Security Officer	:	Mr. C.P. Prajapati

Promotions

Name	Promoted to	Date of promotion
Scientists		
Dr. Kamta Prasad	Senior Scientist	July 5, 2016
Dr. Ram Ratan Verma	Senior Scientist	January 8, 2016
Technical		
Sh. Ghanshyam Ram	Chief Technical Officer	August 16, 2017
Sh. M.H. Ansari	Chief Technical Officer	February 24, 2018
Sh. Adil Zubair	Chief Technical Officer	February 24, 2018
Sh. Vinayak Sawant	Chief Technical Officer	May 04, 2018
Administration		
Sh. Prashant Kamal Srivastava	Asstt. Administrative Officer	December 20, 2019
Sh. Arjun	Assistant	April 10, 2019

Transfers

Name and Post	From	To	With effect from
Scientist			
Dr. Niranjan Lal, Senior Scientist & Head	ICAR-KVK, Churachandpur, Manipur Centre, Imphal (ICAR Research Complex for NEH Region, Umiam, Meghalaya)	ICAR-IISR, Lucknow	April 12, 2019
Sh. Sanjay Kumar Goswami, Scientist (Plant Pathology)	ICAR-NBAIM, Mau, (U.P.)	ICAR-IISR, Lucknow	December 26, 2019
Administration			
Sh. Saroj Kumar Singh, Senior Administrative Officer	ICAR-IIWM, Bhubneswar (Odisha)	ICAR-IISR, Lucknow	July 1, 2019

Superannuation

Name of official	Post held	Date of retirement
Mr. Nar Singh	Chief Technical Officer	May 31, 2019
Mr. Mahendra Pratap Singh	Skilled Supporting Staff	July 31, 2019
Mr. Harish Chandra	Senior Technical Assistant	July 31, 2019
Mr. Suresh Chandra	Senior Technician	July 31, 2019
Mr. Sunder Lal	Assistant	September 30, 2019
Mr. Vishwa Nath	Upper Division Clerk	October 31, 2019
Mr. Shri Ram	Technician	October 31, 2019
Mr. Jai Prakash Pandey	Technical Officer	November 30, 2019
Mr. Shiv Kumar	Technician	December 31, 2019

CHAPTER 22

Meteorological Data

Important weather parameters during April 2019 to December 2019 at ICAR-Indian Institute of Sugarcane Research, Lucknow

Month	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Rainy days (No.)	Bright sunshine hours (hrs./day)	Evaporation (mm/day)	Wind speed (km/hr.)
	Maximum	Minimum	7:18 am	14:18 pm					
April 2019	37.2	20.5	66.7	27.6	2.2	0	9.1	6.4	3.6
May 2019	41.2	24.0	47.6	21.1	0.8	0	9.5	9.6	5.2
June 2019	39.4	26.0	67.7	41.0	62.0	2	7.7	7.0	4.0
July 2019	34.2	24.6	88.6	71.0	417.6	14	5.1	4.5	2.8
August 2019	33.9	24.4	91.6	74.7	275.9	13	6.5	3.7	2.3
September 2019	31.9	22.7	94.3	79.9	341.2	11	4.2	2.4	1.6
October 2019	31.3	15.8	95.2	57.4	5.0	1	5.9	2.2	1.1
November 2019	28.7	13.8	93.1	45.8	0	0	5.3	2.0	1.8
December 2019	20.2	7.9	94.6	59.2	21.6	2	4.0	1.2	2.0

Notes

Notes

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