भाकृअनुप
ICAR

भारतीय गन्ना अनुसंधान संस्थान, लखनऊ
ISO 9001:2015

Annual Report
2021

ICAR-INDIAN INSTITUTE OF SUGARCANE RESEARCH
LUCKNOW - 226 002

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From the Director's Desk

It is a matter of great pride that there was record sugarcane production in the country, which exceeded 500 million tonnes during 2021-22, with the highest ever average productivity of 84.44 t/ha. About 35.8 million tonnes of sugar was produced during 2021-22 marketing season (after discounting 35 lakh MT diversion to ethanol). Exports were the highest at 10.98 million tonnes and sugar mills and distilleries generated ₹ 18,000 crores from sale of ethanol. Ninety five per cent of cane dues were cleared by the end of the sugar season. This unprecedented success in sugarcane production could be possible due to strong research and extension network for sugarcane production in the country. The present Annual Report of the Institute highlights the significant research and extension related achievements in this direction made at the main Institute Campus, its regional stations [centres at Motipur (Bihar) and Pravaranagar (Maharashtra) as well as two KVKs at Lucknow and Lakhimpur Kheri in Uttar Pradesh during the year 2021. These efforts have contributed in the sugarcane development in India and more so in sub-tropical region.

Under Crop Improvement Programme, a mid-late maturing sugarcane variety, CoLk 14204 (*Ikshu*-8) was released and notified by the CVRC for commercial cultivation in North West Zone of India. Another early maturing sugarcane variety, CoLk 14201 (*Ikshu*-10) was also notified by CVRC for cultivation in Uttar Pradesh. Two sugarcane varieties, *viz.,* CoLk 15201 (Early group) and CoLk 15207 (Mid-late group) for North West Zone of India and one variety, CoLk 15466 (Early) for North Central and North Eastern Zone of India were also identified for its release. Six clones were also accepted for multi-location testing at the centres of AICRP on Sugarcane. The collection of 360 genotypes including 183 commercial hybrids, 51 ISH & *Ikshu* ISH lines, 71 LG clones and 30 species level genotypes is being maintained in the Institute. During the year, approximately 8,100 quintals of quality seed cane was also produced.

Crop Production Research was targeted for efficient resource use in sugarcane plant and ratoon crop as well as for improving the yield levels of ratoon crop. Research on efficient resource use focused on developing efficient cropping sequence and efficient sugarcane based integrated farming system modules for small farm conditions having potential of generating additional income up to ₹ 2.66 lakh per ha. Water management research focused on applying irrigation water in trenches along with the use of trash mulch. Under weed management research, the yield reduction in different varieties due to *Ipomoea* spp. infestation was assessed. Suitable recommendations comprising the application of silica and efficient use of K in ratoon crop were developed to substantially increase ratoon crop yields under drip irrigation conditions. The crop production research also focused on nano-urea application in sugarcane.

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

Under Plant Physiology and Biochemistry, multiple abiotic stress responsive genes using transcriptomics indicated that drought caused maximum reduction in growth parameters and impacted the physiological parameters adversely while waterlogging led to maximum increase in catalase and peroxidase activities. Differential expression analysis of transcriptome analysis was also carried out to assess the impact of drought, salinity and water logging. Studies on biomass accumulation with the use of PGR were also carried out to assess the relative effectiveness.

Under Agricultural Engineering, different types of tractor operated prototypes were developed and field tested. These include prototypes of two row disc type ratoon management device with and without stubble shaving attachments, fabrication of a prototype of sugarcane trash management machine to cover two rows of sugarcane, a prototype of two row deep furrow sugarcane cutter planter with design modifications for adjustable row spacing of 120 and 150 cm to make it suitable for tropical region and a prototype of multipurpose tool frame with attachments for furrow opening, interculturing and earthing up, the IISR designed deep furrower was demonstrated at farmers' field in about 8.84 ha area in Biswan Sugar Mill area of Sitapur. With modifications in metering mechanism, tractor operated cane node planter was also developed.

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

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

(A.D. Pathak)
Director

Contents

Executive Summary

Crop Improvement

- A mid-late maturing sugarcane variety CoLk 14204 (*Ikshu*-8) was released and notified by the CVRC for commercial cultivation in North West Zone of India.
- Another early maturing sugarcane variety, CoLk 14201 (*Ikshu*-10) which was earlier released by the U.P. State SVRC for the commercial cultivation in Uttar Pradesh was also notified by CVRC for cultivation in Uttar Pradesh.
- Two sugarcane varieties, *viz.*, CoLk 15201 (Early group) and CoLk 15207 (Mid-late group) were identified by the Varietal Identification Committee of AICRP on Sugarcane for their release in North West Zone of India. Another sugarcane variety CoLk 15466 (Early) was also identified for its release in North Central and North Eastern Zone of India.
- Three early maturing sugarcane clones, *i.e.*, CoLk 21201 (LG 17130), CoLk 21202 (LG 16169) and CoLk 21203 (LG 14418) and three mid-late maturing clones *viz.*, CoLk 21204 (LG 17154), CoLk 21205 (LG 13431) and CoLk 21206 (LG 15166) were accepted for multi-location testing in North West Zone of India.
- The collection of 360 genotypes consisting of *Saccharum officinarum*, *S. barberi*, *S. sinense*, ISH clones, *Ikshu* ISH clones, LG selections, commercial hybrids, somaclonal variants *etc.*, was maintained and the required material was supplied to various ongoing projects of the Institute. The collection includes 183 commercial hybrids, 51 ISH & *Ikshu* ISH lines, 71 LG clones and 30 species level genotypes.
- Approximately, 8,100 quintals of seed cane was produced during the year.

Crop Production

- Application of 26% recommended doses of potassium up to 110 days stage and remaining 74% RDF of potassium through drip between 110-190 day stage produced higher number of shoot count at 45 days after initiation of 2nd ratoon. The 2nd ratoon cane yield (85.80 t/ha) was 64% higher in recommended NPK application through drip over conventional method.
- Among different sources of silicon, diatomaceous earth exhibited superiority over foliar spray of potassium silicate and control. Significantly the highest growth and yield attributes were recorded under the silicon application @ 400 kg/ha.
- Application of 100% N.P.K.+ use of Biostimulator derivative @ 2.5 ml/l of water + sett treatment with *Gluconoacetobacter diazotrophicus* + sett treatment with *Bacillus subtilis* and *Bacillus cerelus* and foliar application of GA_3 @ 35 ppm at 90, 120 and 150 DAP) have been found the best treatment in increasing sugarcane yield (75.08 t/ha) by 14.25% over the recommended NPK.
- Microbial consortia with 75% RDF improved the cane (13.5%) and sugar yield (20.4 %) compared to 100% RDF without microbial consortia (72.2 t/ha and 7.88 t/ha).
- In nano urea modulation, stable cellulose aerogel was prepared by grafting porous silica on the surface by *in situ* hydrolysis. This aerogel shows ~ 70% more absorption capacity in the 5th cycle. The coated urea pellet with 50% of standard recommended dose showing a ~ 70% yield increase along with enhanced physiological parameters like photosynthesis, transpiration and stomatal conductance at its vegetative stage.
- The highest ratoon (111.7 tonnes/ha) and sugar yields (15.04 t/ha) was recorded in February initiated ratoon.
- Grid (70*70 meter) based surface soil analysis results revealed neutral to alkaline soil reaction of ICAR-IISR Research Farm with an average pH value of 8.1. Organic carbon content showed variation from low to high, however, mean status was found in medium range (0.52%).
- Among the moisture regimes, water saturated condition achieved significantly higher growth, yield attributing characters and ratoon cane yield over optimum and sub-optimum regime.
- Water irrigating sugarcane at IW/CPE ratio 0.8 was found the most efficient for water economy and enhancement of water productivity in sugarcane with very little yield penalty. Trash mulching was more effective when irrigation was applied in trenches or alternate trenches. Water footprint of spring planted sugarcane in sub-tropics ranges between 118 and 130 L/kg depending on the irrigation regime and moisture management practices.
- Among different varieties of sugarcane infested with *Ipomoea sp.*, CoJ 64, Co 0238 and CoS 08279 were severely affected while varieties CoLk 11206, CoLk 12203, CoPb 14181 and CoPant 14222 were affected by less than 10% in terms of reduction in cane length, girth, weight, millable canes and cane yield.

- Significantly the highest cane yield (90.0 t/ha) of plant sugarcane crop was recorded under *Tulsi-Stevia*- Sugarcane (Spring) - Sugarcane Ratoon-Mint cropping sequence as compared to cane yield (54.0 t/ha) in Rice-Wheat-Sugarcane (Spring) - Sugarcane Ratoon-Wheat cropping sequence.
- Intercropping cropping sequence in sugarcane based integrated farming system, the results indicated that autumn sugarcane based integrated farming system as Sugarcane + Vegetables (Garlic, Fenugreek, Coriander, Tomato, Cauliflower, Spinach, Carrot, Fababean, Onion, Brinjal, Green chilli, Cabbage, Pea, *Soya, Sauf,* Bottle guard, Okra, Cowpea, Cucurbit, Maize) + Horticultural Crop (*Karonda* boundary plantation + Papaya + Banana) + Backyard Poultry (Breed, *Asheel, Nirbheek, Kadaknath,* Quail) + Dairy unit (Breed- Sahiwal) + Fisheries (*Rohu, Catla, Nain*) + Vermicompost (*Erucina fotida*)+ Apiculture + Mushroom fetched net income ₹ 4,48,202.5/ha and fetched additional income of ₹ 2,65,902.5/ha.
- Zero tillage with residue retention recorded increase in sugarcane yield in plant crop (77.93 t/ha) to the tune of 11.92% over without residue management.

Crop Protection

- Surveillance of sugarcane insect pests and diseases on commercially cultivated varieties was carried out in command area of 12 different sugar mills in Uttar Pradesh, 2 sugar mills in Madhya Pradesh, 4 sugar mills in Bihar and 6 sugar mills in Maharashtra. In UP, in general, incidence of red rot was very high (50-90%) in the variety Co 0238. Incidence of Pokkah boeng is increasing substantially and it is mostly affecting the early sugarcane crop. In variety Co 0238, incidence of top borer, stalk borer, web mite and white fly was observed at certain locations. In Bihar, incidence of red rot in the variety Co 0238 ranged between 50 and 70%. Pokkah boeng was also noticed up to 20% with the variety in most of the locations. In Maharashtra, 80% area of the sugarcane was under CoM 265 with only 10% to 15% area under Co 86032 variety. The major incidences of disease *viz.*, brown spot, rust and *pokkah boeng* were observed in the range of 60-97%, 50-85% and 21-30%, respectively. Among the insect pest infestations, the white grub was observed to be in sporadic areas causing damage in the range of 40- 80%, whitefly infestation was observed in the range of 25-75%. However, the infestations of woolly aphid, pyrilla, internode and early shoot borer was reported in the range of 20-40%.
- Among different anti-protozoan chemicals evaluated for their bio-efficacy against termites reared on artificial diet under laboratory condition, Ornidazole and Tinidazole were the most effective in causing 100 per cent mortality of termites within 11 days of treatment. Two species of the spirochete bacteria *Treponema viz., T. azotonutricium* and *T. primitia* were identified as the most prevalent bacterial species in termite gut.
- Top and internode borer damage was significantly higher in NPK treated plots, while it was lower in FYM treated plots under low SOC soils. The initial organic content of the soil had no significant impact on the population of culturable bacteria population, actinomycetes and *Trichoderma* spp. and bacterivore nematodes. Under low organic carbon, various pesticide treatments stimulated total culturable fungal population. There was no impact of various treatments on total fungal, bacterial, actinomycetes populations in high organic carbon soil.
- Laboratory experiment was conducted to find out efficacy of extracted female semiochemical towards male moth attraction. Adults of *T. chilonis* (collected from egg masses of top borer) were fed on nectar and flower solution of various flowers. Development period for egg to adult varied from 7.2-8.2 days depending on diet. The highest fecundity was observed in flower solutions of lilly, orange *lantana* and red *hibiscus* (40.2-49.0). Honey-water solution and ixora flower solutions as a food source yielded maximum adult progeny (153.1-179.2%). The female progeny (>70%) was observed in all nutrition regimes except red rose flower.
- *Tetrastichus howardi* was reared on larva and pupa of pink borer, internode borer, top borer. Field parasitisation of larvae of top borer (first to fourth broods) by three parasitoids *i.e., Isotima javensis, Rhaconotus scirpophagae* and *Stenobracon niceviilae* was observed in some varieties. The mortality of larvae of top borer by three parasitoids was high in third brood (43.3-54.0%) and fourth brood (35.3-72.9%) in all these identified varieties.
- Seventy-six germplasm were screened against red rot (CF 08 and CF 13) and smut during 2021-22.
- Twenty-four ISH genotypes were tested for red rot resistance for both the pathotypes (CF 08 and CF 13) by plug method of inoculation and by nodal method of inoculation. Fourteen genotypes were rated as moderately resistant (MR) to both the pathotypes (CF 08 and CF 13) by plug method of inoculation and resistant (R) by nodal method of inoculation.

- *Trichoderma* as sett treatment and as foliar spray showed reduction in Pokkah Boeng disease of sugarcane disease.
- The studies on growth rate of fungus of wilt disease and impact of application of *Trichoderma* isolates on smut disease incidence were also conducted.
- A total of 3,853 images of healthy and infested symptoms of different insect, pests and diseases of sugarcane were captured and categorised into 23 different classes to develop the image dataset.
- A total of eighty-seven germplasm of sugar beet were screened during December, 2020-March, 2021 against foliar disease incidence. The major diseases observed during the period were Phoma leaf blight, Alternaria leaf spot, *Cercopsora* leaf spot, *Fusarium* yellows and viral disease complex. Among the eighty-seven germplasm, more than 60 were moderately resistant to the foliar diseases.

Plant Physiology and Biochemistry

- In a study on molecular abiotic stress responses using transcriptomics during sugarcane plant growth, multiple abiotic stress responsive genes indicated that amongst multiple abiotic stresses, drought caused maximum reduction in growth parameters and impacted the physiological parameters adversely while waterlogging led to maximum increase in catalase and peroxidase activities. Transcriptomic analysis depicted a total number of 94,037, 94,226, 93,530 and 94,005 transcripts under control, drought, salinity and waterlogging treatments, respectively. Differential expression analysis revealed 177, 690 and 500 significantly up-regulated transcripts under drought salinity and waterlogging conditions. Whereas, 1961, 2074 and 2008 genes were found significantly down-regulated under drought salinity and waterlogging treatments, respectively.
- Four genotypes under waterlogging indicated changes in photosynthetic pigments, chlorophyll a & b, total Chl, carotenoids, Chl a/b, total Chl / CAR and SPAD index. Under waterlogging conditions, 447,196 transcripts were identified with an average length of 509 bp (N50= 621) for the *de novo* assembly of 2,96,518 unigenes with an average length of 529 bp (N50=664).
- Twelve sugarcane genotypes were assessed for water use efficiency traits in combination with photosynthetic performances and offered a better screening strategy for water use efficiency traits.
- Invigoration of biomass dynamics during sugarcane growth cycle through PGRs *vis a vis* IBA, 6BA and NAA each along with water, *Ethrel* and absolute control using CoLk 94184 assessed for both plant and ratoon crops indicated that biometric traits and biomass accumulation decreased in order of *Ethrel* @ 100 ppm > NAA @ 50 ppm > water> control till harvest (330 DAP).
- Pretreated sugarcane trash processed for efficient hydrolysis through construction of cellulase cocktail *via* statistical method enabled efficient hydrolysis and enhanced ethanol recovery. SSF process through combination of the optimized cocktail and a xylose-fermenting fungus could be expected as a promising system for ethanol production from sugarcane trash.

Agricultural Engineering

- Two prototypes of tractor operated two row disc type ratoon management device with and without stubble shaving attachments were developed for carrying out ratoon initiation operations in sugarcane ratoon field. Machine performed well during field trials.
- The prototype of IISR developed multipurpose tool frame with attachments for furrow opening, interculturing and earthing up was demonstrated at farmers' field in more than 8.84 ha area in Biswan Sugar mill area of Sitapur district. The IISR designed deep furrower were used as an attachment for furrow opening and earthing up operations. The capacity of the machine was 0.48 ha/h for inter-row interculturing with 78% field efficiency.
- In tractor operated cane node planter, cane node metering mechanism was modified, spring loaded pusher was developed and incorporated for efficient metering of cane nodes during planting. Planter was field tested. Effective field capacity of the planter was 0.15-0.17 ha/h.
- The new prototype of sugarcane trash management machine was fabricated for covering two rows of sugarcane.
- Memorandum of Agreement (MoA) was signed with M/s Pishon Technologies, Coimbatore for commercial production of deep furrow sugarcane cutter planter.
- Prototype of disc type ratoon management device (Disc RMD) was modified. Modified prototype of Disc RMD was fabricated at IISR and supplied to ICAR-SBI, Coimbatore for conducting its field adoptability trials in tropical region. Under AICRP on Farm Implements and Machinery (FIM), 113 prototypes of various machines/implements were fabricated and 64 prototypes were supplied to various organizations/persons.

Agricultural Economics, Statistics and ICT

- Sugar trade and export opportunities for Indian sweeteners were analysed. India benefitted from sugar exports in the recent years due to high global sugar prices on account of decline in sugar production in Thailand and some other Asian countries. India's share in world sugar exports increased from 3.5% in 2017-18 to 7.5% during 2020-21, elevating India's position as third largest sugar exporter. Wide fluctuations in sugar export quantity, higher domestic sugar prices compared to international prices and domestic demand are the cause of concern to be managed efficiently.
- In another study, sugarcane growing districts in major cane growing districts were grouped into four zones based on their potential for growing sugarcane. In UP, 62-90% of the sugarcane cultivation is carried out in the most efficient zone, while in other states *viz.*, Maharashtra, Karnataka and Tamil Nadu the most efficient sugarcane cultivation covers 69.04%, 59.11% and 62.47% area, respectively.
- Under agricultural statistics research, the extant of variability of sugarcane experiments conducted under AICRP on Sugarcane during 1991 to 2020 in fine agro-climate zone was determined and analyzed by using mixed model analysis. Also efficiency of designs in sugarcane field experiments was worked out and Alpha Lattice Design (ALD) was found superior than RCBD.
- In the field of information technology, a web based reporting system for the trials of AICRP on Sugarcane was developed and generated number of profiles for recording of zonal varietal and other experimental trials. Efforts have also been made to incorporate AI based systems in sugarcane.

Extension and Training

- Under entrepreneurship development activities, a total of 114 seed cane plots in 46 ha area were maintained in fields of more than 50 farmers. A total of 2,758.60 tonne seed cane was produced out of which 71.02% (1,959.20 t) was utilized as seed material. The overall average net profit and B:C ratio recorded for seed cane crops was ₹ 3,22,323 per ha and 2.48, respectively. Farmers who raised seed cane crops, earned 97.74 per cent more profit over conventional cropping. Considerable increases in all the attributes of EB (full form) was recorded.
- Due to introduction of cane based interventions in sugar mill command area, the average yield of cane increased from 548 q/ha to 710 qt/ha and net income of farmers from cane cultivation increased by 1.9 times (from ₹ 70,000 per ha in the year 2016-17 to ₹ 1,32,000 per ha in the year 2020-2021). A total of ₹ 66.34 million additional annual income from sugarcane reported to be earned by farmers in the project areas. The income of marginal, small and large farmers enhanced by 105.87, 63.73 and 50.14 per cent, respectively.
- The highest net profit of ₹ 6,98,000/ha with B:C ratio 3.87 was recorded in case of banana grown as intercrop with sugarcane in farmers fields.
- A pilot project on the use of drone for spraying of agro-chemicals in standing crop of sugarcane with all provisional precautionary measures was implemented in two villages and factory farm in Loni in Hardoi district of Uttar Pradesh.
- A total of 15 residential capacity building programmes for farmers/development personnel/ entrepreneurs and students were organized. Fifteen field days were organized in different locations of the country.
- Collaboration with Shukla Bandhu Organic Producer Company Limited, Biswan, Sitapur (U.P.) was developed to establish a "sugarcane based Model Farm" at Purwa Dasapur, Sitapur for promoting agribusiness among rural youth.
- Five farmers were developed as entrepreneurs for doing seed cane business.

About the Institute

The Indian Institute of Sugarcane Research (IISR), Lucknow was established in 1952 by the Indian Central Sugarcane Committee for conducting research on fundamental and applied aspects of sugarcane 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

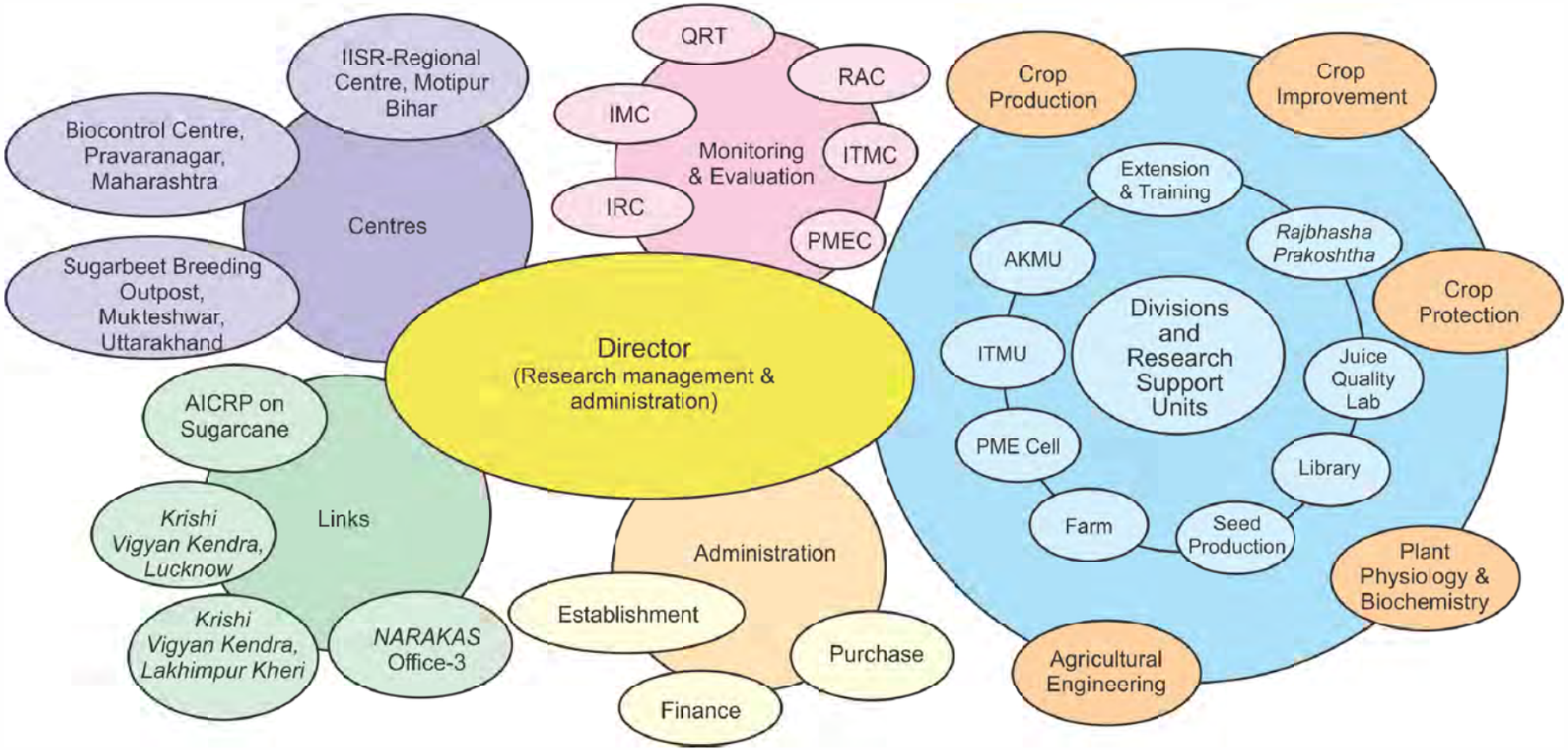
d. Reducing cost of pesticide use in an eco-friendly manner through bio-intensive IPM and IDM

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

Budget: 2020-21

Particulars	Plan (₹ in lakh)	
	Revised Estimate	Expenditure as on March 31, 2021
ICAR-Indian Institute of Sugarcane Research, Lucknow	Salary and Pension: 5147.19 Crop Science: 2194.69	Salary and Pension: 5143.26 Crop Science: 2175.77
All India Coordinated Research Project on Sugarcane	Salary and Pension: 652.86 Crop Science: 200.00	Salary and Pension: 652.86 Crop Science: 194.62

Budget: 2021-22

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

Staff Position

(As on December 31, 2021)

Category	Sanctioned	Filled	Vacant
Research Management Position	1	1	0
Scientific			
Principal Scientist	7	4	3
Senior Scientist	14	15	-1
Scientist	53	44	9
Total	**74**	**63**	**11**
Technical			
Category-I	77	37	40
Category-II	54	27	27
Category-III	3	1	2
Total	**134**	**65**	**69**
Administrative	50	36	14
Skilled Supporting Staff	36	11	25
Grand Total	**294**	**175**	**119**

CHAPTER 1

Genetic Improvement of Sugarcane for Higher Cane and Sugar Productivity

Technology development

Release of sugarcane varieties

A mid-late maturing sugarcane variety CoLk 14204 (*Ikshu* 8) was released and notified by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties of Agricultural Crops for commercial cultivation in the North West Zone of India vide the Gazette of India Notification S.O. 8(E) dated December. 24, 2021. Another early maturing sugarcane variety, CoLk 14201 (*Ikshu* 10) which was earlier released by the U.P. State Sugarcane Varietal Release Committee for the commercial cultivation in all the three zones of Uttar Pradesh was also notified by Central Sub-Committee on Crop Standards, Notification and Release of Varieties vide the Gazette of India Notification S.O. 8(E) dated December. 24, 2021 for cultivation in Uttar Pradesh. Some key features and attributes of the two varieties are mentioned in Table 1.1.

Identification of sugarcane varieties

Two sugarcane varieties, *viz.*, CoLk 15201 (Early group) and CoLk 15207 (Mid-late group) were identified by the Varietal Identification Committee of All India Coordinated Research Project on Sugarcane for their release in the North West Zone of India (Table 1.2). Another sugarcane variety CoLk 15466 (Early) was also identified by the Varietal Identification Committee of AICRP-Sugarcane for its release in the North Central and North Eastern Zones of India.

Sugarcane clones accepted for multi-location testing

Three early maturing sugarcane clones, *i.e.*, CoLk 21201 (LG 17130), CoLk 21202 (LG 16169) and CoLk 21203 (LG 14418) and three mid-late maturing clones CoLk 21204 (LG 17154), CoLk 21205 (LG 13431) and CoLk 21206 (LG 15166) were accepted for multi-location testing in the North West Zone of India during the online Group Meeting-2021 of AICRP(S) organized by ICAR-IISR, Lucknow (Table 1.3).

Table 1.1. Salient features of newly released and notified sugarcane varieties CoLk 14204 (*Ikshu* 8) and CoLk 14201 (*Ikshu* 10)

Variety	Parentage	Maturity group	Cane yield (t/ha)	CCS yield (t/ha)	Sucrose % at harvest	Pol % cane at harvest
CoLk 14204 (*Ikshu* 8)	CoLk 8102 × CoSe 92423	Mid-late	92.73	11.39	17.73	13.83
CoLk 14201 (*Ikshu* 10)	Co 0238 GC	Early	81.99	10.55	18.67	13.86

Fig. 1.1. Field view of the plants and buds of CoLk 14204

Fig. 1.2. Field view of the plants and buds of CoLk 14201

Table 1.2. Salient features of sugarcane varieties CoLk 15201, CoLk 15207 and CoLk 15466

Variety	Parentage	Maturity group	Cane yield (t/ha)	CCS (t/ha)	Sucrose % at harvest	Pol % cane at harvest	Recommended Zone
CoLk 15201 (*Ikshu* 11)	CoS 8436 GC	Early	93.92	11.44	17.64	13.60	North West Zone
CoLk 15207 (*Ikshu* 12)	Co 0238 GC	Early	84.53	10.97	18.71	14.52	North West Zone
CoLk 15466 (*Ikshu* 13)	CoS 8436 GC	Early	85.97	10.41	17.54	13.54	North Central & North Eastern Zone

Table 1.3. 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
CoLk 21201 (LG 17130)	LG 01118 × Co 1158	Early	97.49	12.54	18.48	MR
CoLk 21202 (LG 16169)	CoH 100 GC	Early	96.09	12.28	18.47	MR
CoLk 21203 (LG 14418)	LG 01118 × CoLk 97147	Early	93.11	11.94	18.39	MR
CoLk 21204 (LG 17154)	CoH 106 GC	Mid-late	103.77	15.33	21.24	MR
CoLk 21205 (LG 13431)	LG 01118 GC	Mid-late	101.59	15.10	21.24	MR
CoLk 21206 (LG 15166)	CoS 8436 × CoPant 97222	Mid-late	94.96	14.13	21.39	MR

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

The collection of 360 genotypes consisting of *Saccharum officinarum*, *S. barberi*, *S. sinense*, ISH clones, Ikshu ISH clones, LG selections, commercial hybrids, 25 somaclonal variants, *etc.*, was maintained and the required material was supplied to various ongoing projects of the Institute. The collection includes 183 commercial hybrids, 51 ISH & *Ikshu* ISH lines, 71 LG clones and 30 species level genotypes. DUS desriptor-based characterization is being carried out for the LG clones in the collection.

Development of sugarcane varieties for sub-tropics

Hybridization and seedling raising

A total of 43 bi-parental sugarcane crosses were attempted during the crossing season 2021. Out of that, 34 crosses were attempted at National Hybridization Garden, ICAR-SBI, Coimbatore, while nine were attempted at National Distant Hybridization Facility (NDHF), Agali. Five sugarcane crosses (Baragua × CoS 8436, IK 76-81 Eri × Co 06015, CoC 671 × ISH 229, ISH 100 × CoPant 97222 and Co 0238 × ISH 69) were effected specially for the development of climate resilient sugarcane varieties. In addition, fluff of two poly-crosses (PCs) and 23 GCs was also received from the ICAR-SBI, Coimbatore which will be sown in the glass/poly house for raising the seedlings. Approximately, 17,650 seedlings derived from 23 biparental crosses, 06 PCs, and 53 GCs were raised and transplanted in the field conditions for their evaluation.

Selection in seedling (C_0) Population

Based on the HR Brix and other growth parameters, a total of 513 clones were selected from the seedling populations and have been planted as C_1 clones along with standard varieties for their further evaluation.

Evaluation of advanced clonal generations

A total of 58 promising sugarcane clones were selected from C_1 population were promoted to the C_2 generation for their further evaluation. Similarly, 63 promising sugarcane clones were selected from C_2 generation and promoted to the C_3 generation. Among these clones, the best promising ones were planted in replicated trials for their yield and quality evaluation and also evaluated for red rot disease. Based on the yield, quality and red rot ratings, the best seven promising clones, *viz.*, LG 15256, LG 17137, LG 17213, LG 17214, LG 17219, LG 17224 and LG 17234 were included in the Station Trial (2021-22) for their evaluation.

Station Trial (2020-21)

Ten elite sugarcane genotypes (LG 13431, LG 14418, LG 14497, LG 15166, LG 15265, LG 16169, LG 17129, LG 17130, LG 17154, LG 17179) along with six standard varieties, *viz.*, Co 0238, Co 05009, CoJ 64, CoS 767, CoPant 97222 and Co 05011 were evaluated in Station Trial (2020-21) for their growth, yield and quality parameters. The genotype LG 17129 recorded the highest cane yield (107.32 t/ha) which was significantly superior to the best standard, followed by the LG 17154 (103.77 t/ha) and LG 13431 (101.59 t/ha) (Table 1.4). Similarly, LG 17129 had also shown the highest CCS yield (15.78 t/ha) at harvest followed by LG 17154 (15.33 t/ha) and LG 13431 (15.10 t/ha). The highest sucrose percentage at 360 days was recorded in LG 17130 (21.99%) followed by LG 14418 (21.85%) and LG 15166 (21.39%). However, at 300 days, the highest sucrose per cent was recorded in LG 17179 (18.50%) followed by LG 17130 (18.48%) and LG 16169 (18.47%). Among the standards, Co 0238 was found the best for all the parameters at both 300 and 360 days.

Evaluation of early sugarcane clones for North West Zone

Initial Varietal Trial (Early): A trial comprising of seven test sugarcane genotypes, *viz.*, CoLk 17201, CoLk 17202, CoLk 17203, CoPb 17211, CoPb 17212 CoPant 17221 and CoS 17231 and three standards (CoJ 64, Co 0238, Co 05009) was conducted and observations were recorded on various yield and quality parameters. CoLk 17201 recorded the highest cane yield (98.76 t/ha) closely

Table 1.4. Performance of elite sugarcane genotypes under Station Trial (2020-21)

Entry	Cane Yield (t/ha)	CCS Yield (t/ha)	Sucrose % (360 d)	Sucrose % (300 d)
LG 13431	101.59	15.10	21.24	17.82
LG 14418	93.11	11.94	21.85	18.39
LG 14497	98.94	13.88	20.10	17.66
LG 15166	94.96	14.13	21.39	18.08
LG 15265	82.60	12.22	21.21	17.52
LG 16169	96.09	12.28	21.28	18.47
LG 17129	107.32	15.78	21.07	17.65
LG 17130	97.49	12.54	21.99	18.48
LG 17154	103.77	15.33	21.24	17.50
LG 17179	99.25	14.68	20.96	18.50
Standards				
Co 0238	81.44	12.22	21.58	18.27
CoJ 64	76.99	11.22	20.93	17.96
Co 05009	61.83	8.98	20.69	17.65
CoS 767	71.46	10.15	20.25	17.60
CoPant 97222	75.42	11.32	21.30	17.87
Co 05011	72.71	10.92	21.47	17.45
Mean	88.44	13.09	21.16	17.93
SE (m)	5.51	0.87	0.56	0.35
CD@5%	11.25	1.77	ns	0.72
CV %	7.63	8.11	3.25	2.41

followed by CoPant 17221 (79.14 t/ha). The genotype CoLk 17201 had shown the highest CCS yield (11.19 t/ha) followed by CoLk 17202 (8.73 t/ha). The highest sucrose content at harvest was recorded in CoS 17231 (16.80%) followed by CoLk 17202 (16.65%). Among the standards, Co 0238 was found the best standard for both yield and quality parameters and recorded the highest cane yield (81.80 t/ha) and CCS yield (9.62 t/ha).

Advanced Varietal Trial I-Plant (Early): Six sugarcane genotypes, *viz*., Co 15025, Co 16029, CoLk 14201, CoLk 16201, CoLk 16202 and CoPb 16181 along with three standards, CoJ 64, Co 0238 and Co 05009 were evaluated for yield and quality parameters. Among the test genotypes, CoLk 14201 recorded the highest cane yield (105.48 t/ha) followed by CoLk 16202 (120.21 t/ha) and CoLk 16201 (99.85 t/ha). Similarly, CoLk 16202 recorded the highest CCS yield (13.46 t/ha) followed by CoLk 14201 (13.42 t/ha) and CoLk 16201 (12.34 t/ha). The genotype CoLk 16202 showed the highest sucrose percentage at harvest (18.97%) followed by CoLk 14201 (18.30%) and CoPb 16181 (18.02%). Among the standards, Co 0238 was the best check for cane yield (81.40 t/ha) and CCS yield (11.13 t/ha).

Advanced Varietal Trial II-Plant (Early): Six sugarcane clones, *viz*., Co 15023, Co 15024, Co 15027, CoLk 15201, CoLk 15205 and CoPb 15212 along with three standards, CoJ 64, Co 0238 and Co 05009 were evaluated for yield and quality parameters. Among the test genotypes, CoLk 15201 recorded the highest cane yield (116.53 t/ha) and CCS yield (14.89 t/ha). The genotype Co 15023 showed the highest sucrose percentage at harvest (19.02%) followed by CoLk 15201 (18.48%). Among the standards, Co 0238 was the best check for cane yield (83.33 t/ha) and CCS yield (10.70 t/ha).

Advanced Varietal Trial-Ratoon (Early): Six sugarcane clones, *viz*., Co 15023, Co 15024, Co 15027, CoLk 15201, CoLk 15205 and CoPb 15212 along with three standards, CoJ 64, Co 0238 and Co 05009 were evaluated for their ratooning ability. The genotype CoLk 15201 had shown the highest cane yield (91.79 t/ha) and CCS yield (11.04 t/ha). Among the standard varieties, Co 0238 was the best for cane yield (69.61t/ha) and CoJ 64 for CCS yield (8.26 t/ha).

Seed Multiplication (Early): The seed of eight sugarcane genotypes, *viz*., CoLk 18201, CoLk 18202, CoPb 18181, CoPb 18182, CoPb 18211, CoPb 18212, CoPant 18221 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): Fifteen sugarcane clones, *viz*., Co 17018, CoLk 17204, CoLk 17205, CoPb 17213, CoPb 17214, CoPb 17215, CoPant 17223, CoPant 17224, CoS 17233, CoS 17234, CoS 17235, CoS 17236, CoS 17237, CoH 17261 and CoH 17262 along with three standards, *viz*., CoS 767, CoPant 97222 and Co 05011 were evaluated for yield and quality parameters. The genotype, CoPb 17214 recorded the highest cane yield (98.78 t/ha) followed by CoPant 17223 (97.05 t/ha) and CoS 17233 (94.33 t/ha). The genotype, CoPb 17214 recorded the highest CCS yield (13.89 t/ha) followed by CoS 17235 (13.13 t/ha) and CoS 17233 (12.93 t/ha). Among the test genotypes, Co 17018 recorded the highest sucrose percentage at harvest (20.50%) followed by CoS 17235 (20.27%) and CoPb 17214 (20.13%). Among the standard varieties, CoPant 97222 recorded the highest CCS yield (11.39 t/ha) followed by Co 05011 and CoS 767.

Advanced Varietal Trial I-Plant (Mid-late): Five sugarcane genotypes, *viz*., Co 16030, CoLk 16203, CoLk 16204, CoS 16232 and CoS 16233 along with three standards, CoS 767, CoPant 97222 and Co 05011 were evaluated for yield and quality parameters. The genotype CoLk 16204 recorded the highest cane yield (101.44 t/ha) which was significantly superior to the best check. CoS 16233 exhibited the highest sucrose at harvest (21.01%) followed by CoLk 16204 (20.55%) and CoLk 16203 (20.15%). Among the standard varieties, CoPant 97222 was found the best for cane yield (83.30 t/ha) and CCS yield (12.05 t/ha).

Advanced Varietal Trial II-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) were evaluated for yield and quality

parameters. The genotype, CoLk 15207 recorded the highest cane yield (102.95 t/ha) which was significantly superior to the best check. Similarly, CoLk 15207 exhibited the highest sucrose at harvest (21.93%) followed by CoS 15232 (21.54%) and CoLk 15206 (20.86%). Among the standard varieties, Co 05011 was found the best for cane yield (79.59 t/ha) and CCS yield (11.33 t/ha).

Advanced Varietal Trial-Ratoon (Mid-late): Seven genotypes, *viz*., Co 15026, CoLk 15206, CoLk 15207, CoLk 15209, CoPb 15213, CoS 15232 and CoS 15233 along with three standard varieties, CoS 767, CoPant 97222 and Co 05011 were evaluated for their ratooning ability. The genotype CoLk 15207 had shown the highest cane yield (90.34 t/ha) and CCS yield (11.32 t/ha). Among the standard varieties, Co 05011 and CoPant 97222 both were on par for cane yield as well as CCS yield.

Seed multiplication (Mid-late): The seed of eleven genotypes, *viz*., Co 18021, Co 18022, CoLk 18203, CoLk 18204, CoPb 18213, CoPb 18214, CoPant 18221, CoS 18231, CoS 18232, CoS 18233 and CoS 18234 is being multiplied for next year's IVT trial.

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

The project aims for population improvement for high sugar accumulation potential in the sub-tropical sugarcane genotypes and to develop high sugar sugarcane genetic stocks. The high sugar genotypes developed in earlier projects will also be characterized in this newly initiated project. The already developed high sugar genotypes will be used as parents for developing populations with improvement in sugar accumulation potential. During October-November 2021, approximately 20 matings involving the high sugar genotypes recently included in the NHG, at ICAR-SBI, Coimbatore, *viz*., LG 01118, LG 08422, LLG 09475, LG 09487, LG 11440, LG 14564, LG 14482, and improved sugarcane varieties were carried out during the crossing season 2021-22. This also included a few crosses involving *S. officinarum* clones at Distant Hybridization Facility, ICAR-SBI RC, Agali, Kerala. The fluff from the crosses of earlier seasons (2020-21) was sown in the mist chamber. The juice analysis was initiated in the different clonal generations from the month of October-November 2021. Out of the 150 promising clones studied in November, 13 clones exhibited more than 18% sucrose in juice in the month of November 2021. The evaluation will be continued in the subsequent months for selecting the promising genotypes.

Mapping of loci linked to sugar content in sugarcane

The project aims evaluation of promising sugarcane genotypes and identification of high sugar sugarcane genetic stocks and also to carry out molecular mapping of loci linked to sugar content, using segregating populations. From October 2021 onwards, the objective of evaluation and identification of high sugar genetic stocks will be taken care of in a newly initiated inter-institutional project for population improvement.

The high sugar genotypes evaluated during 2020-21 exhibited variation in sugar content, and out of the 250 genotypes evaluated in different clonal stages, 25 genotypes exhibited mean sucrose % in juice values >18.5% in January/at harvest (Table 1.5). These are being assessed further in 2021-22 for their performance and suitability as genetic stocks and/or varietal candidates. Majority of the clones in different maturity groups selected were advanced for another round of evaluation in 2021-22. Among 37 clones tested, four moderately resistant/resistant to red rot disease with no wilt symptoms were identified.

During 2021-22, a total of 40 genotypes with mean sucrose % in juice values >19% in January/at harvest are being evaluated. All these genotypes qualify as high sugar early maturing (in January) or mid-late maturing (in February-March) genotypes. These clones will be tested in the divisional station trial for suitability as varietal candidates, depending on sugar and cane yield and reaction to diseases like red rot. Another trial evaluates ~160 genotypes in the third and fourth clonal stages, that have been advanced from the previous year. Hand Refractometer Brix readings were recorded in October-November, 2021 in these genotypes and the promising clones were earmarked. The morphological studies and juice analyses were initiated from November 2021. From the various trials, 20 clones were identified with high sucrose content (>17% sucrose in juice) in November 2021. Three promising clones, LG 14440, LG14467 and LG 14474 are being evaluated in the divisional station trial, out of which two (LG 14440 and LG 14474) have been reported to be severely affected by wilt. The incidence of the disease was observed in the trial laid out in the project also. The progeny of the crosses involving the high sugar genetic stock LG 07501 (GC and bi-parental crosses) exhibited high sucrose % in juice values, indicating that this high sugar genotype may be promising as a good parental clone.

Thirty promising genotypes in different clonal stages are being tested for reaction to red rot disease during the year. Segregating populations for molecular marker studies were maintained in the field. The mean sucrose % in juice at harvest varied from 8.8% to 20.9%.

Differences were observed with respect to the variation for sucrose content in populations from self and bi-parental cross involving the genotype CoLk 7901. Genotyping studies were initiated using the segregating population.

Table 1.5. Performance of promising high sugar genotypes for sugar content

Genotype	Sucrose % in juice at harvest	CCS %
I-38-01	18.85	12.89
II-29-20	18.75	12.77
II-06-10	19.08	13.07
II-16-01	18.52	12.64
I-33-2	18.90	13.24
I-6-2	18.77	13.08
III-25-10	18.83	13.11
IV-13-2	18.66	12.93
III-25-8	19.29	13.39
III-19-10	18.62	12.89
III-21-5	19.38	13.57
III-53-7	19.75	13.80
III-18-2	18.98	13.36
III-12-7	19.34	13.64
III-25-2	18.58	13.00
III-19-2	19.01	13.32
III-20-8	18.69	13.17
III-26-9	19.21	13.52
I-20-10	20.09	14.15
III-17-3	18.65	12.96
IV-35-06	19.03	13.38
III-11-7	19.37	13.66
III-24-1	18.68	12.60
III-27-4	19.27	13.31
III-26-3	19.28	13.42

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

In order to study the differential proteome profile of sugarcane during *Colletotrichum falcatum* infection, red rot resistant (BO 91) and susceptible (CoJ 64) cultivars of sugarcane were raised in field and inoculated the plants at grand growth phase (7 months after planting) with virulent pathotype of *C. falcatum* CF 08. The sugarcane stalk samples of both the varieties were collected at 3, 6 and 24 h after inoculation along with control. The samples were sent for the LC-MS/MS proteomic expression analysis. LC-MS/MS proteomic data has been received and is under process for abundance analysis of proteins.

To study the comparative proteomic profile of *C. falcatum*, the pathogen was co-cultured on potato dextrose broth with susceptible variety CoJ 64. A standard highly virulent pathotype of *C. falcatum* Cf 08, isolated from variety CoJ 64 and maintained in plant pathology laboratory at IISR was used in the present study. Briefly, half-strength and one fourth-strength potato dextrose broth (PDB) was prepared and poured in 150 ml flasks @ 50 ml PDB/flask. For co-culture, apparently healthy stalks of variety CoJ 64 were selected, washed and the outer hard layer of the stalks was removed. The inner internodal stalk tissue was cut in small bits (0.5-1.0 cm) and added to flasks containing PDB @ 1.5 g bits/flask. Control flasks without stalk tissue were maintained for both half-strength and one fourth-strength PDB. All the flasks were sterilized by autoclaving at 121^{0}C for 15 minutes. For inoculation in flasks, spore suspension of *C. falcatum* pathotype CF 08 was prepared in sterile water from a 10-day old pure sporulating culture of CF 08 grown on oat meal agar in Petri plates. The cfu of the suspension was adjusted to 10^6 spores/ml and each flask was inoculated with 1.0 ml of spore suspension with five replications each for half-strength PDB, one fourth-strength PDB and their respective controls. The inoculated flasks were incubated under stationary conditions at 28±2^{0}C for 7 days after which the mycelium was collected by filtration, rinsed with deionized water and stored at -80^{0}C for further studies. The co-cultured mycelium (with sugarcane stalks) along with control were analysed for differentially expressed proteins by LCMS-MS. J-VENNY analysis indicated that out of total 3,665 proteins detected in *C. falcatum*, 538 proteins were expressed exclusively in control *C. falcatum* samples, whereas, 874 and 630 proteins expressed in treatment 1 (1/4 strength PDB) and treatment 2 (1/2 strength PDB), respectively.

Fig. 1.3. J-VENNY analysis of *C. falcatum* proteins showing exclusive abundance in response to red rot infection in sugarcane stalks

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

Micropropagation technique of plant tissue culture is useful for rapid multiplication of new varieties with superior traits and production of disease-free genetically uniform seed cane. Virus indexed mother stock cultures of sugarcane variety CoLk 14201 were supplied to UP Cooperative Sugar Mills Federation. *In vitro* cultures of new sugarcane varieties CoLk 14201 (*Ikshu* 10) and CoLk 14204 (*Ikshu* 8) were multiplied through enhanced axillary shoot proliferation using apical shoot explants, and transferred to field conditions. 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, CoLk 11206, CoLk 12207 and CoLk 12209 that were transferred to field last year were harvested and utilized as seed cane.

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, 0.5 µM 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, 0.5 µM 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. Successful shoot multiplication without any genetic variation in the recovered cultures was recorded from such stored slow-growing shoots.

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 NCS-TCP. The aim of ATL is to support the tissue culture production units for testing of mother stock and TC plants so as to ensure genetically uniform and virus-free planting materials to the farmers. During the year 2021, a total of 9,520 samples were tested, out of which 3,090 samples comprising of 30 samples of sugarcane and 3,060 samples of banana from DBT recognized tissue culture production facilities were tested for mother stock virus indexing. Of the total samples, 6,430 samples of banana were tested for genetic fidelity testing, which equals to quality certification of 65 lakh tissue culture plantlets, for which test reports and certificate of quality were issued as per DBT Guidelines. The testing included 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). Considering the importance of virus-free and genetically uniform planting materials, DBT, New Delhi has further extended the Accredited Test Laboratory (ATL) of IISR, Lucknow for another five years (October 2021-September. 2026) with total outlay of ₹ 148.56 lakh.

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

Sucrose is the prime product of sugarcane and a significant variation has been observed among different sugarcane genotypes for the time taken to initiate sucrose accumulation. High sucrose accumulation in sugarcane at early crop phase is one of the most desirable traits, since it can help in reducing its long growth cycle. This study is based on a segregating population raised in sub-tropical India, where, sucrose accumulation starts at ~10-month crop stage. RNA-seq data of two extreme bulks from a segregating full-sib population and its parents were used to identify differential genes and single nucleotide polymorphisms (SNPs) associated with early season high sucrose accumulation. A total of 49 common significantly differential genes were identified between high- and low- sucrose parents and bulks among which chlorophyll a-b binding protein and psaK were observed as initial points of sucrose-mediated feedback regulation. The high sucrose accumulation during early season coincided with upregulation of transcription factors (TIFY10a and ERF), and genes related to arabinogalactans, glutaredoxin, ethylene and amino acid transporters as well as downregulation of genes for solute transport (PUP, STP) and hormones (ABA and IAA). Further, six of the identified early sucrose linked DEGs, *viz.*, ethylene-responsive transcription factor 1 (AP 2), TIFY, YUCCA, Monosaccharide transporter 2, Photosystem I reaction centre subunit psaK, and chlorophyll a-b binding protein were validated for similar patterns of differential expression in a panel of sugarcane genotypes comprising the two parents and three varieties each showing early

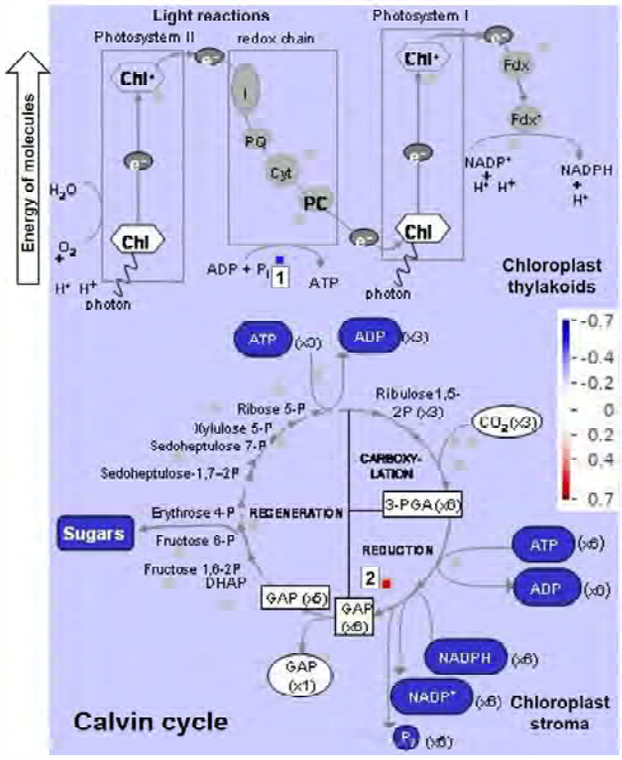


Fig. 1.4. Highly significant differentially enriched SNP identified on genes involved in photosynthesis. The numbers denote chlorophyll a-b binding protein 1B-21 chloroplastic (1), and aminomethyl transferase component T-protein of glycine cleavage system (2)

season high and low sucrose accumulation. This study was further able to identify significantly differential SNPs located pre-dominantly on several transcription factors, receptor kinases, glucuronosyltransferase, callose synthase, microRNA biogenesis complex and phytohormone action. These preliminary results provide useful insights into the role of differential genes and allelic heterozygosity in early season sucrose accumulation in sugarcane.

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

Approximately 500 highly diverse sugarcane genotypes from different sugarcane research centres were chosen as training population. Their genotyping using 10 ISSR markers is completed. The marker data analysed for population structure identification and a 'Training Population' of 192 genotypes has been constituted, which would be able to capture the maximum available diversity. The 'Training Population' has been phenotyped for sucrose content and NMCs. Paired-end libraries was prepared for RE-GBS using a rare and a common cutter restriction enzyme followed by ligation with barcoded adaptors (4-10 nucleotides in length). In order to choose a restriction enzyme for GBS *in silico* restriction digestion analysis of sugarcane genome using *Saccharum* hybrid cultivar SP80-3280 downloaded from NCBI was carried out. *PstI* which is a six base methylation sensitive cutter and has been used in all previously reported GBS studies was compared to a five-base cutter *ApeKI*, and based on the results, *ApeKI* was chosen as the restriction enzyme for GBS. The library pools were sequenced on Illumina HiSeq 2000 platform to generate an average of 1 GB data per sample. SNP calling from the GBS data has been completed in the training population. The prediction of appropriate Genomic Selection model and calculation of GEBV values for identification of superior clones is underway.

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

Differentially expressed miRNA under red rot challenged conditions from BO 91 and CoJ 64 (red rot resistant and susceptible sugarcane varieties respectively) were taken as an input for prediction of targets which belonged to protein binding transcription factors, transporter proteins, enzyme regulator activity, nucleic acid binding transcription factors, disease-resistance proteins and response to stimulus *etc.* RT-qPCR was performed to establish the relation between the differentially expressed miRNAs and the respective target gene transcripts. Total RNA was isolated at temporal intervals of 24, 48 and 72 hrs. from stalks of these varieties of sugarcane inoculated with *C. falcatum* (CF 08) along with the control samples using Trizol reagent and cDNA was synthesized. The stem loop RT-PCR primers and target gene-specifc primers were designed and the qRT-PCR expression analysis was performed with AriaMx REAL-TIME PCR SYSTEM ™ (Agilent Technologies, USA). The results indicated that miR162b, miRNA164a, miR164c, miR166d & miR6233-5p have a regulatory effect on the expression of respective target genes in most of the cases.

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

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

Seed production in agricultural crops (ICAR Seed Project)

During year 2021, approximately 8,100 quintals of seed cane was produced (Table 1.6). The lifting of Seed Cane was excellent, with Seed Cane of CoLk 14201 and CoLk 11203 being lifted in the Seed bags each containing 100 three-budded setts. The price of each Seed Bag was fixed at ₹ 500.00. In addition, 13.0 ha area planted with newly released varieties for seed cane production during 2022-23. New varieties, *viz.*, CoLk 15201, CoLk 15207 and CoLk 15466 were included in the seed production from the current year. Under Seed Cane Awareness, seed of newly released varieties CoLk 11206, CoLk 11203, CoLk 12207, CoLk 12209, CoLk 14201 and CoLk 14204 were distributed to farmers and several sugar industries for making the sugarcane growers aware about the role of new varieties and the quality seed cane in enhancing the yield and production. Field Days to popularize recently notified varieties were organized at the Institute.

Table 1.6. Sugarcane seed production at ICAR-IISR, Lucknow during 2021

Variety	Group	Quantity (q)
CoLk 14201	Early	2000
CoLk 12207	Early	100
CoLk 11203	Early	1000
CoLk 9709	Early	500
CoLk 94184	Early	800
CoPk 05191	Early	100
Co 0238	Early	200
Co 0118	Early	100
Co 05011	Mid-late	100
CoLk 09204	Mid-late	1500
CoLk 11206	Mid-late	1000
CoLk 14204	Mid-late	200
CoLk 12209	Mid-late	400
Total		**8,100**

Awareness for morphological identification of varieties with DUS characters under field condition was also taken-up with development staff and farmers.

CHAPTER 2

Natural Resource Management

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

Among weeds, morning glories comprise a very important group of climbing plants that infest sugarcane crop. *Ipomoea* spp. emerge late and develop during the large growth phase of sugarcane fields and can compete with the crop. Studies conducted worldwide have shown that the yield losses due to binding weeds range from 20-25%. Knowing the phonological stages, the cycle of weed species, as well as the production and distribution of their masses, allows the elaboration of an integrated weed management of weeds. Knowing how the growth of the *Ipomoea* species occurs also allows interference on the competitive ability of the plants. Therefore, the aim of the studies was to evaluate growth and development characteristics of the *Ipomoea* spp. under different time of emergence. The results of the studies are summarised as below:

A. Biology of *Ipomoea* spp. under different time of emergence

Month of seeding and germination

Days taken to germination of *Ipomoea* species were recorded after every successive time of seeding. The pots sown with *Ipomoea* seeds in the month of February and March took 9 and 7 days to complete their germination, respectively. While, pots sown in the subsequent months from April to August, 4 to 5 days taken for complete germination (Fig. 2.1). The February and March sown pots took longer time to germinate possible because of lower temperature prevailing in these months.

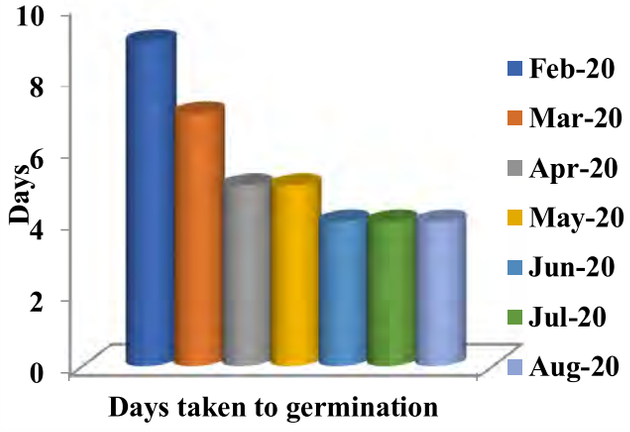


Fig. 2.1. Effect of seeding month on germination of *Ipomoea* sp.

Month of emergence and weed plant height

Emergence month affected the plant height of the *Ipomoea* species and it was observed that the plant height was increased with increase in the stages of growth with irrespective to their month of emergence. Plant height of the *Ipomoea* species at 2 to 3 months after emergence in February and March sown pots were lower compared to pots sown in subsequent months (Fig. 2.2). At this stage of growth, higher plant height was recorded with the pots sown in April and May which were significantly higher over other treatments. However, at later stages of growth *i.e.*, 6 to 7 months after emergence, February and March sown pots had higher plant height of *Ipomoea* spp. It might be due to more period available for the growth with *Ipomoea* sown in the February and March month.

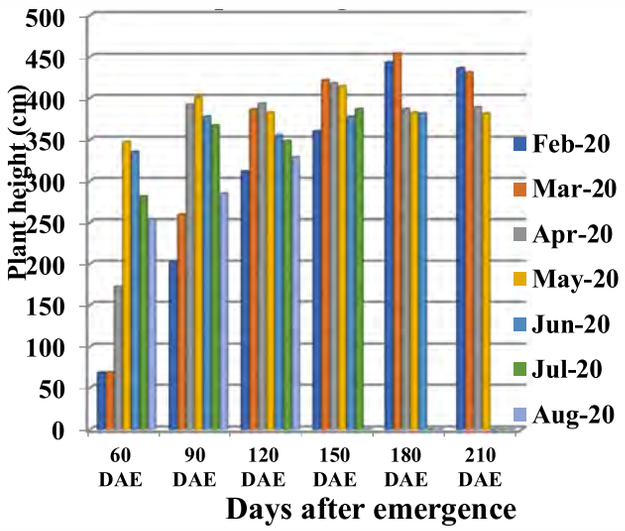


Fig. 2.2. Effect of date of seeding on *Ipomoea* plant height

Month of emergence and weed root length

Similar to plant height, root length of *Ipomoea* spp. were also influenced with their month of emergence. At initial stages of growth *i.e.*, two months after emergence of the *Ipomoea* spp., lower root length was recorded with the pots sown in the month of February to April compared to the plants emerged in the subsequent months. But at the later stages of the growth, higher root length was recorded with the plant emerged in the month of February to May compared with the plants emerged in June, July and August months, respectively. The lowest root length occurred with the plants emerged in the month of August (Fig. 2.3).

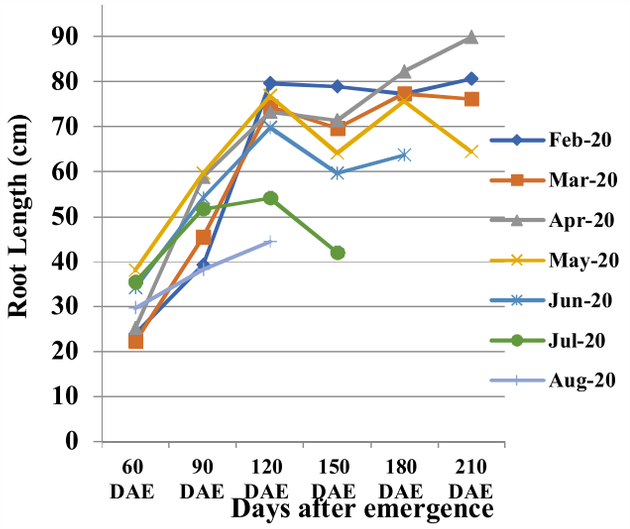


Fig. 2.3. Effect of date of seeding on root length

Month of emergence and weed plant dry matter

The initial increase in plant dry weight in February and March emerged *Ipomoea* spp. for a period of three months after emergence were lower than the plant dry weight gained in April onward emerged *Ipomoea* plant. At later stages of growth, the plant dry matter accumulated was significantly higher with the pots sown in the month of February and March. It might be due to plant got more period for their vegetative growth and development. The lower weed dry matter accumulation occurred with the pots sown in the month of June onward. The results indicated that the *Ipomoea* spp. emerged in the February to May may accumulated more weed plant dry matter because of longer period available for their vegetative growth and caused more competition to the sugarcane crop (Fig. 2.4). The least weed plant dry weight was recorded in the pots sown in August.

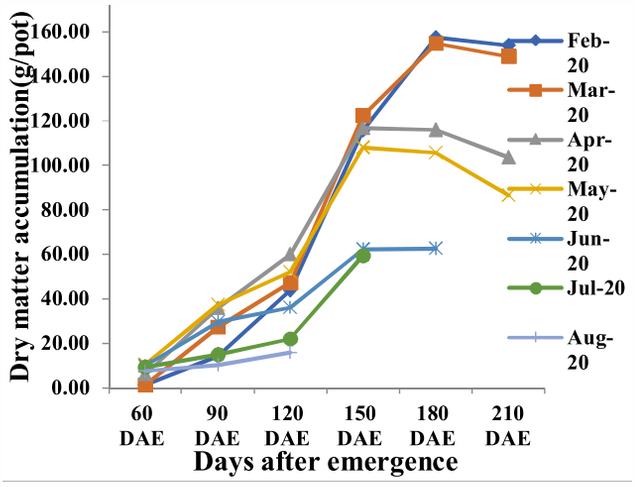


Fig. 2.4. Effect of date of seeding weed on dry matter accumulation

Month of emergence and weed root dry weight

Similar to weed plant biomass accumulation, the root biomass accumulation was also influenced due to their month of emergence. During initial period of growth *i.e.* 2 to 4 months of emergence, the lower root biomass accumulation occurred with the pots sown in February and March, respectively (Fig. 2.5). Afterward in succeeding months, the root biomass accumulation was almost similar with the pots sown in the months of February to May. However, the highest root biomass accumulation was occurred under February sown pots and the lowest root biomass accumulation occurred with the pots sown in August. Reason could be lesser time available for their vegetative growth.

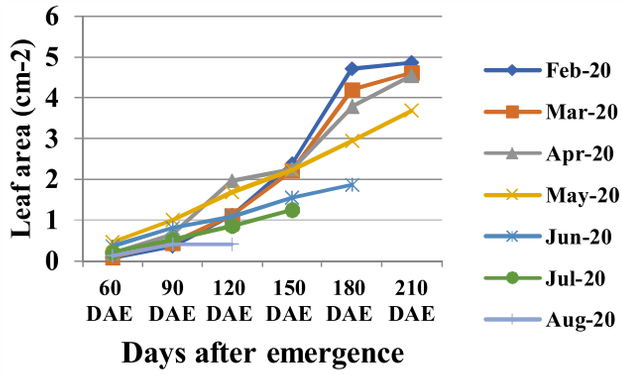


Fig. 2.5. Effect of date of seeding on weed root dry weight

Month of emergence and seed production

Numerous factors are responsible for increase or decrease in the seed production capacity of the plant, Findings of this studies indicated that the highest seed production per pot as well as per plant basis was recorded with the pot sown in the months of February and March, respectively followed by the pots sown in the months of April to July (Fig. 2.6). The lowest seed production per plant occurred under August sown pot.

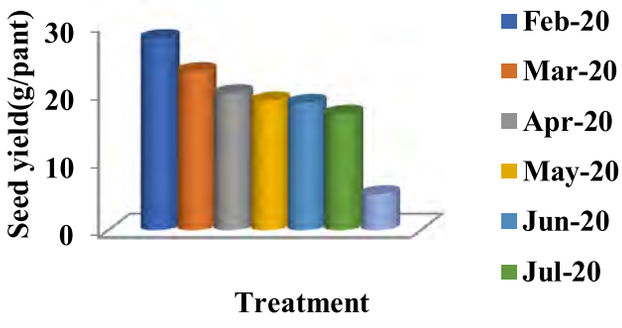


Fig. 2.6. Effect of date of seeding on seed yield of *Ipomoea* sp.

B. Evaluation of competitiveness of sugarcane varieties against *Ipomoea* spp.

Findings indicated that all the varieties of sugarcane undertaken for study differed significantly

in their competitiveness in respect to smothering the vine weed. Among different varieties, the varieties namely CoLk 11206, CoLk 12203, CoPb 14181 and CoPant 14222 were affected by less than 10% in terms of reduction in cane length, girth, weight, NMC and cane yield indicating more competitive ability over other varieties. However, the highest impact of *Ipomoea* sp. infestation in the respect to reduction in cane parameters and yield was noted with varieties CoJ 64, Co 0238 and CoS 08279 due to severe competition caused by *Ipomoea* sp. infestation. In these varieties, the top plane of the crop was fully covered by these binding weeds, which completely check the blocking of solar radiation on top plane of sugarcane. It may be concluded from this study that the problem caused due to *Ipomoea* sp. infestation could be minimized by replacing the varieties having highly competitive ability.

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

Effect of ratoon initiation date and NPK along with organic manure on different parameters of sugarcane

Observations on second ratoon recorded as ratoon initiated as per date of planting *i.e.* of February followed by March, April and May. Tiller population number showed that February initiated ratoon recorded the highest number of tillers at 180, 210 and 240 days after ratoon initiation (DARI). It was significantly higher than April and May initiated ratoon and statistically at par with March started ratoon. Tiller counted at 180 DARI was significantly higher tiller count than May but at par with March initiated ratoon. February initiated ratoon crop gave slightly higher number of plant population than March, April and May crop at 210 DARI though it was not affected significantly. Similarly, February started date recorded statistically superior number of plant tillers than remaining three dates of starting at 240 DARI. March initiated ratoon was statistically higher than April and May initiated ratoon crops. It was found there were no statistical differences found regarding number of tillers counted at different stages in treatment recommended NPK, NPK through using STCR without IPNS and NPK through using STCR with IPNS at 180, 210, and 240 DARI. Whereas tiller population recorded with recommended NPK slightly higher number of plant tillers at 180 DARI followed by NPK through using STCR without IPNS and NPK through using STCR With IPNS. Similar trend was also observed at 210 DARI, though NPK through using STCR with IPNS recorded higher number of tillerswith NPK through using STCR with IPNS at 210 DARI. While at 240 DARI slightly higher number of tillers was recorded in NPK through using STCR with IPNS followed by recommended NPK and NPK through using STCR without IPNS. Initially higher numbers of plant tillers were found in the treatment recommended NPK but at later stage at 240 DARI NPK through using STCR with IPNS recorded the highest number of tillers.

Yield and CCS as affected by days of ratoon initiation and STCR based nutrient application

The highest yield was recorded in the February initiated ratoon crop followed by March, April and May initiated crop. It was statistically higher than April and May crop at par with March crop (Table 2.1). Higher yield in the aforesaid treatment might be due to higher number of yield attributing characters such as NMC and single cane length, girth and weight. However, February initiated crop also reflected 8.6, 28.6 and 32.7% higher yield than March, April and May crop, respectively.

Table 2.1. Effect of days of ratoon initiation and STCR based nutrient application on tiller population of second ratoon, yield and CCS of first ratoon

Main plot (Date of planting)	1st ratoon		2nd ratoon Tillers count (000/ha)		
	Yield (t/ha)	CCS (t/ha)	180 DARI	210 DARI	240 DARI
February	111.7	15.04	144222.2	145814.8	126740.8
March	102.1	13.77	129185.2	136259.3	112481.5
April	79.7	10.86	123777.8	129925.9	97037.0
May	75.2	10.22	109555.6	119148.2	88518.5
SE (m)	5.3	0.65	4553.8	NS	12577.3
CD (p=0.05)	18.7	2.29	16064.5	10070.7	3565.3
Sub-plot					
Recommended NPK	90.6	12.18	128361.1	133805.6	102388.9
NPK through using STCR without IPNS	94.4	12.70	126555.6	131833.3	107916.7
NPK through using STCR with IPNS	91.7	12.53	125138.9	132722.2	108277.8
SE (m)	2.1	0.27	3227.8	3922.7	4191.7
CD (P≤0.05)	NS	NS	NS	NS	NS

DARI: Days after ratoon initiation

Similarly, CCS yield also followed the similar trends as it was depended on two factors *i.e.* sucrose content and yield in that particular treatment and remaining treatments. Targeted yield approach using STCR techniques to apply required quantity of nutrients to achieve respective yield, it was observed that application of NPK through using STCR with IPNS gave slightly higher tillers counts at different stages and NMC was relatively higher than recommended dose of NPK and NPK through using STCR without IPNS. Through this STCR approach, we have achieved targeted yield during February and March initiated ratoon.

- Statistically higher yield and CCS 111.7 t/ha and 15.4 t/ha, respectively, were achieved from February than other months of ratoon initiation.
- NPK through using STCR without IPNS treatment gave slightly higher yield than remaining treatments.
- Experiment No. 2 on weed control has also been started and ratoon crop initiated with treatments applied.

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

Field experiment to assess 'the effect of conservation agriculture practices on the productivity and profitability of sugarcane-based production system and on soil quality parameters' was initiated during July 2018 (second year) with sowing rice in dry direct seeded rice mode (DSR) followed by sowing of wheat crop and planting of sugarcane followed by sugarcane ratoon. The experiment comprised of 24 treatments in split-split plot design with three replications. In main plots, four treatments *viz.*, conventional tillage without crop residue; conventional tillage with crop residue incorporation; zero tillage without crop residue; zero tillage with crop residue retention and in sub-plots, two treatments *viz*. with and without brown manuring and in sub-sub plots three treatments *viz.*, recommended dose nitrogen of the crop (RDN); 75% of RDN and 125% of RDN.

Sugarcane ratoon was initiated in February 2020 followed by sowing of wheat. Data depicted in Table 2.2 evidenced that tillage practice significantly influenced the tiller number at 45 and 180 days after planting of sugarcane, NMC, cane length, cane diameter and yield of sugarcane. Crop residue management (retention/incorporation of crop residue of previous crop) treatment recorded increase in ratoon cane yield to the tune of 13.5% over to without crop residue management (69.91/ha). However, conventional tillage practice enhanced ratoon productivity only @ 2.30% higher over the zero tillage (73.78/ha). All the doses of nitrogen were found at par with respect to growth and yields of ratoon cane. Crop residue management (retention/incorporation of crop residue of rice and wheat) treatment recorded increase in production of NMC and cane length in sugarcane ratoon tune of 11.25 and 9.59% over without crop residue management, respectively.

Wheat was sown after harvesting of sugarcane ratoon in second fortnight of December 2020. Results depicted in Table 2.3 revealed that tillage management, brown manuring and different nitrogen doses recorded significantly superior in production of effective tillers, 1000 grain weight and yield of wheat grain. Maximum wheat grain yield (40.10 q/ha) recorded with zero tillage practice with crop residues (previous crop) retention, which was recorded 36.4, 28.53 and 17.21 per cent higher yield over the conventional tillage, conventional tillage with crop residues incorporation and zero tillage without crop residue retention, respectively.

Table 2.2. Effect of tillage and management practices on growth, yield and yield attributes of sugarcane ratoon

Treatment	Shoot count ('000/ha)		NMC ('000/ha)	Cane length (cm)	Cane dia. (mm)	Cane yield (t/ha)
	45 DAI	180 DAI				
Conventional tillage with residue retention	122.37	212.00	110.35	281.49	27.81	80.77
Conventional tillage without residue retention	113.88	182.54	98.10	257.19	27.67	70.19
Zero tillage with residue retention	120.77	208.83	107.19	279.76	27.68	77.93
Zero tillage without residue retention	110.80	178.64	97.45	254.93	27.65	69.63
CD (P=0.05)	6.16	11.81	5.633	22.14	1.86	3.68
With brown manuring	117.63	197.28	102.60	269.75	27.93	75.20
Without brown manuring	116.29	193.73	103.95	266.94	27.48	74.06
CD (P=0.05)	NS	NS	NS	NS	NS	NS
75% of Recommended Dose of Nitrogen (RDN)	113.36	183.34	96.15	258.76	26.79	70.32
RDN	117.18	198.79	104.41	270.17	27.93	75.80
125% of RDN	120.33	204.38	109.26	276.10	28.38	77.77
CD (P=0.05)	3.84	5.84	3.271	13.80	1.27	2.25

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

Treatment	Effective tillers/ sm²	1000 grain wt. (g)	Yield (q/ha)
Conventional tillage with crop residue	329.56	36.01	31.20
Conventional tillage	312.11	35.49	29.40
Zero tillage with crop residue	352.50	37.31	40.10
Zero tillage	335.5	36.57	34.21
CD at 5%	21.78	1.05	4.32
Brown manuring	338.00	36.67	35.27
Without brown manuring	326.83	36.01	32.18
CD at 5%	5.50	0.47	1.16
75% of RDN	316.92	36.01	31.70
RDN	335.75	36.47	33.96
125% of RDN	344.58	36.54	35.52
CD at 5%	5.19	0.45	1.03

Evaluation of sugarcane varieties for drought tolerance

A field experiment was initiated during first week of February 2020 to identify drought tolerant varieties suitable for specific agro-climatic condition. The experiment comprising 12 treatment combinations was laid out in strip plot design with three replications. Three early maturing varieties *viz*., CoPk 05191, CoLk 94184 and Co Lk 9709 and three mid-late maturing varieties *viz*., CoLk 09204, CoLk 11206 and CoS 08279 (total 6 varieties) and two irrigation scheduling as strip treatment *viz*., irrigation scheduling at IW/C.P.E. ratio 1.0 (IS 1) and 0.3 (IS 0.30). Sugarcane crop was irrigated 9 times in treatment IW/CPE ratio 1.0 (IS 1.0), and five times in IW/CPE ratio 0.3 (IS 0.3). Crop was irrigated 7.5 cm in depth in each time of irrigation. Well distributed 987.8 mm rainfall was received during the crop duration. Rainfall distributed from June to September. In winter, rainfall occurs in November 2020 only. Among the six varieties of sugarcane (Table 2.4), CoPK 05191 produced the highest NMC, cane diameter, cane yield, juice extraction percentage, CCS. Maximum 91.31 t/ha sugarcane yield was recorded with IS 1.0 with CoPk 05191 followed by CoLk 11206. Cane yield production was recorded significant superior with irrigation scheduling and among varieties. Minimum reduction in sugarcane yield with tune of 10.76 per cent with treatment IS 0.30 over treatment IS 1.0 with variety CoPk 05191 followed by variety CoLk 11206 (13.96%) which was at par with CoLk 94184 (15.19%).

Soil quality assessment under different sugarcane growing systems

An experiment was initiated to assess the effects of three moisture regime *viz*., sub-optimal, optimal and water logged and three fertilizer doses *viz*., farmers practice (FP), recommended dose of fertilizers (RDF) and soil test and targeted yield (STCR) on growth, yield and soil quality in autumn and spring planted sugarcane. The first set of ratoon was initiated from December, 2020 (autumn planted sugarcane) and second set was initiated in February, 2020 (spring planted sugarcane) with three moisture regime and three fertilizers doses in strip plot design with three replications. The results revealed that growth characters *viz*., number of tillers, shoots and plant affected significantly with the alteration of moisture regime at both the season but autumn planted ratoon recorded the highest tillers and shoot counts and plant height than the spring planted ratoon crop. Among the moisture regime, water logging achieved significantly higher growth character over optimum and sub-optimum regimes. Among the fertilizer doses, application of fertilizers based on soil test and targeted yield equations observed significantly higher counts of

Table 2.4. Performance of irrigation scheduling and varieties of sugarcane on production of tillers, NMC, cane yield and commercial cane sugar (CCS)

Treatment	Tillers ('000/ha) (90 DAP)	NMC ('000/ha)	% Extraction juice	Yield (t/ ha)	CCS (t/ha)
A. Irrigation Schedule					
IS1.0	149.36	108.87	61.44	85.52	10.33
IS0.3	133.18	90.16	59.61	69.32	8.26
CD (5%)	9.15	7.82	1.62	5.86	0.68
B. Varieties					
CoLk 94184	144.52	102.51	60.08	79.80	8.64
CoPk 05191	149.49	109.46	61.67	86.40	10.54
CoLk 9709	134.15	91.65	59.64	70.52	8.61
CoLk 09204	136.07	92.90	60.08	71.76	8.83
CoLk 11206	144.71	103.34	60.96	80.64	9.58
CoS 08279	138.67	97.23	60.72	75.41	9.58
CD (5%)	10.05	4.89	0.76	3.58	0.69

tillers and shoots and plant height over RDF and FP. FP found significantly inferior over the RDF and STCR. Almost similar trend was also reported in case of cane girth, cane weight and number of millable canes (Table 2.5). The ratoon yield was better in autumn planted sugarcane than spring planted. The water logging conditions significantly increased cane yield over optimal and sub-optimal conditions at both the season, and increase was 5.33 and 14.4% in autumn planted cane and 4.09 and 14.5% in spring planted cane over optimal and sub-optimal moisture regime, respectively. Similarly, application of mineral fertilizers based on soil test values and targeted yield equation recorded significantly higher cane yield over FP and RDF at both the season. Application of mineral fertilizers based on STCR increased cane yield in the tune of 5.87 and 11.3% at autumn and 5.97 and 11.3% at spring planted crop over RDF and FP, respectively.

Table 2.5. Effect moisture regime on growth, yield attributers and yield of autumn and spring planted ratoon crop

Treatment	Tillers (10³/ha)		Shoot (10³/ha)		Plant height (m)		Cane girth (cm/plant)		Cane weight (kg/plant)		NMC (10³/ha)		Yield (t/ha)	
	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring
Moisture condition														
Sub-optimum	135.5	115.3	105.1	97.8	1.86	1.49	2.26	2.17	0.743	0.707	98.0	81.4	77.8	71.9
Optimum	146.9	140.1	109.3	106.7	1.98	1.55	2.44	2.31	0.794	0.763	103.0	83.8	84.5	78.1
Water logging	160.6	140.8	113.4	114.1	2.07	1.63	2.55	2.39	0.887	0.802	106.7	97.3	89.0	82.3
CD (P=0.05)	6.29	4.86	4.81	7.07	0.68	0.36	0.05	0.04	0.019	0.02	3.40	9.83	4.43	4.13
Fertilizer dose														
FP	133.3	123.3	104.7	97.9	1.85	1.51	2.33	2.16	0.762	0.721	97.8	81.8	79.4	73.4
RDF	155.4	131.4	108.7	106.5	2.00	1.55	2.41	2.29	0.804	0.773	103.1	87.4	83.5	77.1
STCR	154.3	141.6	114.4	114.1	2.06	1.61	2.51	2.42	0.878	0.824	106.9	93.3	88.4	81.7
CD (P=0.05)	4.76	3.95	3.83	5.36	0.72	0.54	0.06	0.09	0.04	0.04	3.19	6.05	3.23	2.96
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

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

A field experiment was conducted during 2018 - 2019 to assess the effect of split application of NPK under drip fertigation on sugarcane in plant and ratoon cane productivity. The experiment comprising 7 treatments was laid out in RBD with 4 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 February 8, 2018. First ratoon cane harvesting was done in first week of February 2020 and was left for 2nd ratoon initiation.

Results revealed that there was significant differences among different treatments on growth parameters in 2nd ratoon sugarcane crop (Table 2.6). Shoot count (000/ha) measured at 45 DAI (Days after ratoon initiation) was recorded higher under application of 100% RDF of NPK (T4) and in 10% higher RDF of NPK (T7) application (181.5 – 184, respectively) over rest of the treatments. The lower shoot count at 45 DAI was recorded in farmers' practice. These two treatments (T4 & T7) were significantly superior over rest of the treatments. The increase in number of shoot at 45 DAI of ratoon over conventional method was 51.62% and 53.71% in T4 & T7, respectively. But there was no significant difference between T4 and T7 in number of shoot recorded at 45 DAI of ratoon initiation. Application of 26% recommended doses of potassium up to 110 days stage and remaining 74% RDF of potassium through drip between 110 and 190 days stage gave higher number of shoot count at 45 DAI over other treatments. Similarly, the superiority of T4 & T7 over T1, T2, T5, and T6 were also observed in tillers count made at 120 and 180 DAI. Shoot count at 210 DAI showed that the T3, T4 and T7were significantly at par while gave significantly higher shoot count over T1, T2 , T5 and T6. Application of fertilizer & irrigation by conventional method was found poor performer with respect to growth observations recorded up to 210 DAI of ratoon.

The 2nd ratoon cane yield was 64% higher in 100% RDF application through drip over conventional method (Table 2.7). Under this treatment, there was an increase in sucrose per cent but the differences with other treatments were non-significant. Beneficial effect of split delivery of different fertilizer through drip irrigation on growth and yield of sugarcane was recorded more in case of N splitting over P&K. Extending the K application up to 6 months period of the initiation of 1st ratoon crop proved beneficial in initial shoot count in 2nd ratoon crop.

The weed dry weight recorded was higher in conventional methods of fertilizer and irrigation practices. In this treatment, the weed dry weight was 1450 kg/ha, while the weed dry weight recorded in all the drip fertigation treatment was low in comparison to the conventional method. The lowest weed dry weight was recorded under 100% RDF of NPK applied at

different duration and with variable rates under drip-fertigation. This might be due to the fact that the conventional methods received flood irrigation which facilitates weeds to take more water and nutrients while under drip fertigation only limited area was irrigated that too between the sugarcane rows, which disfavour the weeds to take water and nutrients in comparison to the crop thus reduced dry weight of weeds were recorded.

Table 2.6. Effect of different treatments on plant growth

Treatment No	Treatment	Shoot count	Tillers count (000) / ha		
		(000)/ ha at 45 DAI	At 120 DAI	At 180 DAI	At 210 DAI
T1	Conventional	119.70	115.78	98.40	68.75
T2	N through drip + PK basal	152.0	165.28	157.50	96.00
T3	NP drip + K basal	163.4	177.10	157.50	115.75
T4	100% NPK drip	181.61	185.08	162.00	113.75
T5	75% NPK drip	153.90	158.40	128.70	91.00
T6	50% NPK drip	120.65	134.20	99.60	70.00
T7	100% NPK through drip *	184.03	189.31	161.10	110.00
	C.D. at 5%	15.75	13.97	7.99	14.38

* 10% additional NPK was applied

Table 2.7. Effect of different treatments on yield attributes and yield

Treatment No	Treatment	NMC/ha (000)	Yield (t/ha)	Weed dry weight (kg/ha)
T1	Conventional	71.00	52.25	1450
T2	N through drip+ PK basal	85.00	69.00	1110
T3	NP drip+ K Basal	87.00	74.00	1050
T4	100% NPK drip	98.00	85.80	975
T5	75% NPK drip	83.00	64.25	1020
T6	50% NPK drip	61.00	47.00	1170
T7	100% NPK through drip*	103.00	88.75	966
C.D. at 5%		12.26	9.05	-

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

Field experiment was carried out with the objective 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 experiment consisted of 10 treatments *viz*. T_1 - Control (No silicon application), T_2 - Silicon @ 200 kg/ha through bagasse ash,T_3 - Silicon @ 400 kg/ ha through bagasse ash, T_4 - Silicon @ 600 kg/ha through bagasse ash, T_5 - Silicon @ 800 kg/ha through bagasse ash, T_6 - Silicon @ 200 kg/ha through diatomaceous earth, T_7 - Silicon @ 400 kg/ha through diatomaceous earth,T_8 - Silicon @ 600 kg/ha through diatomaceous earth,T_9 - Silicon @ 800 kg/ha through diatomaceous earth and T_{10} - Foliar spray of 2.5% Potassium silicate at 60, 90 and 120 DAP. The experiment was laid out in Randomized Block Design with three replications. The experimental crop was planted on April 26, 2020 with a row to row spacing of 75 cm using sugarcane mid late variety CoLk 09204. The three budded treated setts were used to plant the crop at proper soil moisture.

The experimental findings revealed that tillering, NMC, cane length and cane yield indicated significant variations among the treatments (Table 2.8). Though numerically the highest values of above parameters were noted under the effect of silicon application @ 800 kg/ ha but the difference was found significant only up to the level of 400 kg/ha of silicon application. Formation of tillers and number of millable canes (NMC) increased appreciably up to 400 kg/ha of silicon application compared to that with 200 kg/ha of silicon application and control. More or less the similar pattern was observed in cane length also under different treatment. Cane yield increased significantly with increasing levels of silicon up to 400 kg/ha but was at par with the yield levels recorded under higher levels of silicon application. The foliar spray of 2.5% potassium silicate at 60, 90 and 120 DAP showed significant variation in cane yield than control. Among different sources of silicon, diatomaceous earth exhibited numerically better compared to bagasse ash but significantly superior to foliar spray of potassium silicate and control.

Table 2.8. Number of tillers, NMC, cane length and cane yield as influenced by source and dose of silicon

Treatment	Tiller no. (000/ha)	NMC (000/ha)	Cane length (cm)	Yield (t/ha)
Control (No silicon application)	89.55	84.19	242.38	59.30
Silicon @ 200 kg/ha through bagasse ash	96.85	90.04	249.13	65.21
Silicon @ 400 kg/ha through bagasse ash	104.71	97.67	257.40	74.21
Silicon @ 600 kg/ha through bagasse ash,	106.26	98.17	260.55	75.42
Silicon @ 800 kg/ha through bagasse ash	107.26	98.87	261.85	77.96
Silicon @ 200 kg/ha through diatomaceous earth	97.07	90.46	251.20	66.21
Silicon @ 400 kg/ha through diatomaceous earth	105.04	98.16	259.46	75.21
Silicon @ 600 kg/ha through diatomaceous earth	106.3	98.46	261.62	76.78
Silicon @ 800 kg/ha through diatomaceous earth	107.91	99.56	263.17	79.88
Foliar spray of 2.5 % Potassium silicate at 60, 90 and 120 DAP	97.64	91.76	251.28	68.08
SEm ±	2.30	1.64	3.91	1.55
CD (P=0.05)	6.89	4.91	11.71	4.66

Total 120 samples were collected from 0-15 cm depth and 120 from 15-30 cm depth from different blocks of IISR farm. Out of which, 88 samples from both the depths were analyzed (Table 2.9). The MBC (Microbial

Table 2.9. Microbial and enzymatic activities of soil in different blocks of IISR farm

	No of sample	MBC (µg C/g/ soil)		BSR (mg /CO_2-Cg/d)		FDA (µg fluorescein/g/h)		ACP (µg PNP/g/h)		ALP (µg PNP/ g/h)	
		0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
	06	B-Block									
Mini.		213.7	192.3	8.14	7.48	5.53	1.67	60.9	35.9	64.4	58.1
Max.		301.0	282.3	12.1	10.6	16.87	3.83	202.3	82.2	147.6	125.4
Mean		269.2	248.1	10.6	9.53	7.90	2.66	126.4	58.8	107.9	82.4
SD		34.2	33.0	1.47	1.18	4.37	0.95	62.3	16.7	36.0	29.6
CV (%)		12.7	13.3	13.8	12.4	55.3	35.8	49.3	28.4	33.3	35.9
	10	C-Block									
Mini.		185.6	166.7	10.6	8.14	5.00	1.87	99.59	53.97	33.3	29.6
Max.		293.0	273.7	12.3	10.6	10.7	6.13	105.9	91.6	147.6	125.4
Mean		244.2	232.0	11.4	9.9	8.24	3.47	102.3	71.9	77.8	66.3
SD		39.1	40.7	0.70	0.92	2.67	1.59	3.11	16.4	49.2	39.0
CV (%)		16.0	17.5	6.20	9.30	32.5	46.0	3.04	22.8	63.2	58.9
	24	D-Block									
Mini.		254.0	209.8	10.3	7.04	3.30	1.20	145.2	106.9	49.2	39.0
Max.		342.8	302.3	13.4	10.1	20.2	16.5	338.5	216.6	147.6	125.4
Mean		287.7	250.0	11.5	8.21	7.10	4.11	221.0	141.9	84.5	72.4
SD		25.1	26.1	1.03	1.17	6.69	6.06	74.6	48.2	43.7	37.1
CV (%)		8.7	10.4	8.94	14.2	94.2	147.4	33.8	34.0	51.7	51.3
	24	E-Block									
Mini.		245.3	215.1	11.0	9.90	6.60	3.1	44.9	14.6	49.4	20.5
Max.		356.3	301.5	12.5	12.1	30.73	24.5	178.3	47.7	151.8	108.6
Mean		299.7	265.0	11.7	10.6	25.32	14.75	84.4	32.4	96.1	55.5
SD		39.5	34.6	0.70	0.78	3.98	3.52	49.5	13.3	39.7	32.6
CV (%)		13.2	13.1	5.97	7.36	15.7	15.5	58.6	41.0	41.4	58.8
	24	F-Block									
Mini.		245.3	215.1	7.92	6.82	7.20	4.57	58.8	43.2	97.1	35.5
Max.		380.3	320.9	15.2	13.38	29.4	20.2	257.7	135.4	445.3	154.9
Mean		304.8	255.1	12.47	10.72	17.1	13.8	152.5	81.6	211.5	96.6
SD		40.6	29.3	2.11	1.87	14.6	13.4	64.0	27.5	110.8	34.3
CV (%)		13.3	11.5	16.9	17.4	85.1	97.3	42.0	33.7	52.4	35.5

Biomass Carbon) ranged between 185.6 and 380.3 & 166.7 and 320.9 µg C/g soil in 0-15 cm and 15-30 cm, respectively across the blocks. On the basis of mean value, the highest MBC (380.3) was recorded in F block in 0-15 cm depth. Similarly, BSR (Basal Soil Respiration) ranged between 7.92 and 15.2 & 6.82 and 13.38 mg/ CO_2-Cg/d in 0-15 cm and 16-30 cm whereas FDA (Fluorescein Diacetate hydrolytic Activity) ranged between 3.30 and 30.73 and 1.20 and 24.5 µg fluoresce in g/h in 0-15 and 15-30 cm, respectively. ACP (Acid Phosphatase) ranged between 44.9 and 338.5 and 14.6 and 216.6 µg PNP/g/h and ALP (Alkaline Phosphatase) between 33.3 and 445.3 and 20.5 and 154.9 µg PNP/g/ h, respectively in 0-15 cm and 15-30 cm depth of soil.

Management of bioresources for enhancing sugarcane productivity and soil health

The application of chitosan in agriculture is recently becoming 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. This is in conjunction with the other characteristics of chitosan such as low toxicity towards mammalian cells. Bio compatibility and natural occurrence has attracted interest in recent years in research and development aimed towards widening the scope of chitosan. There are so many bio resources *viz*; nitrogen fixing bacteria, PSB, potassium solubilizing bacteria available and hence, there role is already proven for crop production. Plant growth regulators like- GA_3 has also proven for its role in crop growth, and development. Therefore, present study was undertaken to work out efficacy of oligochitosan (Biostimulator) and other bioresources and its integration in sugarcane productivity and soil health.

Keeping in view the above facts, an institute project has been initiated on following objectives:

- To assess the efficacy of biostimulator and biofertilizers on growth, yield and quality of sugarcane.
- To assess the efficacy of biostimulator and biofertilizers on beneficial soil microbes and nutrients status of soil.

Details of treatment evaluated in plant and ratoon cane

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} + Foiliar application of GA_3 @ 35 ppm at 90, 120 and 150 DAP

Note- Sett treatment (for 30 min dipping) with bioresources will be carried out at the time of planting.

*Foliar spray of the biostimulator will be carried out at 45, 75, 105 DAP.

The experiment was conducted in RBD with three replications. Field experiment was conducted on "Management of Bioresources for enhancing sugarcane productivity and soil health" during spring 2021 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. At nutshell, treatment T-7 (100% N.P.K.+Use of biostimulator derivative @ 2.5 ml/l of water+sett treatment with *Gluconoacetobacter diazotrophicus*+sett treatment with *Bacillus subtilis* and *Bacillus cerelus* and foliar application of GA_3 @ 35 ppm at 90, 120 and 150 DAP) have been found best treatment for cane yield (75.08 t/ha) and significantly influenced over other treatment combinations followed by T-11 (73.57 t/ha) and T-9 (72.21 t/ha (Table 2.10). The number of tillers, NMC, cane weight and other growth parameters were also found in similar trends. The initial soil analysis were also done for chemical and biological properties of soil and values are as 0-15 cm depth; Organic Carbon-0.33%, pH-7.90, ECe-0.13 ds/m, N-219 kg/ha, P_2O_5-34.49 kg/ha, K_2O-215.47 kg/ha; however at 15-30 cm depth, the values are as; Organic Carbon-0.25%, pH-8.10, ECe-0.10 ds/m, N-181.88 kg/ha, P_2O_5-19.92 kg/ha, K_2O-191.62 kg/ha. The biological analysis report of this initial samples are Bacteria- $8.8*10^6$, Actynomycies -$3.74*10^4$, Fungi-$9.31*10^4$.

Table 2.10. Effect of bioresources on number of tillers, cane length, cane girth, NMC and cane yield

Treatment	No. of tillers at 120 DAP (000/ha)	No. of tillers at 180 DAP (000/ha)	Cane length (cm)	Cane girth (mm)	NMC (000/ha)	Yield (t/ha)
	Mean	Mean	Mean	Mean	Mean	Mean
T_1: 100% N:P:K (Control)	55.34	66.75	196.07	2193.27	62.81	65.71
T_2: 75% N:P:K (Control)	55.29	65.04	195.00	2164.87	60.73	64.84
T_3: T_1 + Use of Biostimulator derivative @ 2.5 ml/l of water*	53.63	59.01	193.53	2113.47	58.02	64.05
T_4: T_3+ sett treatment (*Gluconacetobacter diazotrophicus*)	62.50	69.59	202.67	2309.67	68.08	70.15
T_5: T_4 + sett treatment (*Bacillus subtilis*)	59.88	67.92	196.33	2195.13	63.17	66.87
T_6: T_5 + sett treatment (*Bacillus cerelus*)	61.38	69.17	198.33	2209.73	67.38	67.78
T_7: T_6 + Foliar application of GA_3 @ 35 ppm at 90, 120 and 150 DAP	72.09	74.51	207.67	2449.20	77.96	75.08
T_8: T_2- Use of biostimulator derivative @ 2.5 ml/l of water*	62.09	69.13	202.33	2230.00	65.87	68.57
T_9: T_8 + sett treatment (*Gluconacetobacter diazotrophicus*)	63.09	72.63	204.67	2354.40	74.13	72.21
T_{10}: T_9 + sett treatment (*Bacillus subtilis*)	59.92	68.54	197.67	2203.80	66.35	66.67
T_{11}: T_{10} + sett treatment (*Bacillus cerelus*)	64.88	73.50	206.33	2392.67	75.27	73.57
T_{12}: T_{11} + Foliar application of GA_3 @ 35 ppm at 90, 120 and 150 DAP	62.88	70.25	203.33	2322.07	73.33	71.26
CD at 5%	7.18	7.12	6.98	141.51	6.48	3.98

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

The field experiment was initiated 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 ratooing system. Nutrient management levels significantly affected the ratoon cane yield (Table 2.12). RDF at 75% (N_1) recorded the highest cane yield (94.7 t/ha) and sugar yield (10.96 t/ha) significantly compared to 50% RDF (N_2) and FYM application @ 15 t/ha (N_3). The 75% RDF combined with microbial consortia superseded the cane yield and sugar yield compared to 100% RDF (C_2). Microbial consortia M_1 (N+ P+ K+ Zn+ S+ Fe) and M_2 (N+ P+ K+ Zn+ S) being at par produced higher cane yield but significant with M_3 (N+ P+ K+ Zn) and M_4 (N+ P+ K). Nutrient management and microbial consortia did not show an interaction effect. FYM at 15 t/ha (N_3) and 50% RDF (N_2) in combination with microbial consortia recorded a similar cane yield with 100% RDF without microbial consortia (C_2). Microbial consortia did not significantly affect growth and quality parameters being at par among all cultures. The higher mean value of soil total bacteria count, soil respiration, SMBC, SMBN, and soil enzymatic activity of dehydrogenase, amylase, urease, alkaline phosphatase were recorded at all growth stages with FYM application @15 t/ha (N_3) closely followed by 75% RDF and 50% RDF in combination with microbial consortia treatments. Application of microbial consortia under different levels of nutrient management improved the soil quality parameters compared to 100% RDF without microbial consortia (C_2). The combination of microbial consortia with chemical fertilizer improved growth and yield attributes at different crop growth stages of the first ratoon crop. Results revealed that application of microbial consortia with 75% RDF (N_1) improved the cane (9.5%) and sugar yield (8.8%) compared to 100% RDF without microbial consortia (C_2).

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

A research project for developing scientific aids for site specific nutrient management through variable mapping of soil properties in sugarcane growing soils was implemented during the year 2021. The project objectives were: 1) to characterize the variability in soil properties, 2) to study the relationship among them and identify most contributing parameters in soil quality, 3) to find out the best fit geo-statistical semivarigram models of soil properties and develop spatial distribution maps and to identify potential soil management zones based on the soil properties status and spatial delineation of identified management zones. The legacy soil micronutrients data of ICAR-Indian Institute of Sugarcane Research Farm were studied. The wide variation was found in the DTPA extractable micronutrients *viz*. Zn, Cu, Fe and Mn. The zinc deficiency was found in the few soil samples. The spatial distribution maps of zinc, copper, iron and manganese were prepared based on the best fit semivariogram model through geo-statistical study. The semivariogram model Hole effect was found the best fitted model for spatial mapping of zinc and iron, K-Bessel for copper and J-Bessel for manganese. The grids of 70x70 meter were created and from each grid, central point was consider as soil sampling point. In this way, 240 soil sampling points were identified and from each sampling point, soil samples were drawn from the soil depth of 0-15 cm and 15-30 cm soil depth. The collected soil samples were processed and analyzed in the laboratory by following the standard methodology. The surface soil analysis results revealed neutral to alkaline soils reaction of ICAR-IISR Research Farm with an average pH of 8.1. Soil electrical conductivity was found in neutral range. Organic carbon content of the soil showed wide variation ranging from low to high; however, an average status was found in medium level (0.52%). The variation in available nitrogen was found from low to medium in status but average status was found in the low status (240.6 kg/h). The wide variation was observed in the availability of phosphorus in the soil which was varied from the low to high in range, however, average status of the samples was found in the medium status. The available potassium was varied from medium to very high in status. On average, cultivated soils of the research farm were found in the medium status, however, soils of the forest area of the research farm were found very high in available potassium status. Research Farm sulphur analysis data showed that about 59% soils were found deficient in sulphur content, 38% in medium status and 3% area was found in high sulphur availability. The DTPA extractable zinc, copper, iron and manages analysis data reveals deficiency of zinc, iron and manganese in certain areas, however, average values of all the studied micronutrients were found above to their critical limits. Sub-surface (15-30 cm depth) soil sample average pH was found higher than the surface soil. However, other soil properties like EC, available nitrogen, phosphorus, potash, sulphur, Zn, Cu, Fe and Mn value were found lower as compared to the surface soil.

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

A field experiment was carried out with the objective to 'develop feasible technology to improve the sugarcane ratoon productivity, profitability and sustainability in multiple ratooning system, with the application of sugarcane bagasse ash (SBA), sulphitation press mud cake, brown manuring and potassium silicate. The experiment consisted of 10 treatments in main plot (Nutritional management) five treatments *viz.*, N_1: Recommended practices of ratoon management, N_2: N_1 + 300 kg Si/ha through sugarcane bagasse ash (SBA), N_3: N_2 + 500 kg SPMC (sulphitation press mud cake), N_4: N_3 + foliar spray of 2.5% potassium silicate at 0, 30 and 60 days of ratoon initiation and N_5: N_5 + brown manuring of *Sesbania* at ratooning, and in sub-plot, two treatment as dates of sugarcane ratoon initiation *viz.* D_1: 15 December & D_2: 15 February.The experiment was initiated with planting of sugarcane on October 24, 2020 in split-plot design with three replications. As per the treatment 'D1', sugarcane ratoon was harvested on December 15, 2021 and treatment was given as per schedule. As per treatment 'D2', rest sugarcane plant crop will be harvested on February 15, 2022.

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

A field experiment to work out the water productivity of sugarcane as influenced under different moisture regimes and management practices was initiated in the spring season of 2021. Planting of sugarcane was done on February 12, 2021 using mid-late variety CoLk 09204. In order to ensure uniform distribution of water in the field, laser levelling was performed before lay out of the treatments. In all, 18 treatments comprising three irrigation regimes (irrigation at 1.0, 0.8 and 0.6 IW:CPE ratio at 75 mm depth of irrigation) and six moisture management techniques (flooding, trench and alternate furrow irrigation each with and without trash mulching) were planted following strip-plot design with three replications. Soil of the field was silty loam in texture with pH 8.2 and infiltration rate 5.2 mm/hr. Medium fertile soil (227, 15.8 and 312 kg NPK) was found medium in soil organic carbon content (0.55%). Sugarcane planting was done in paired row trenches following 120:30 configuration. Pre–sowing irrigation was given 20 days before planting and a general irrigation was provided in all the plots (81 mm) at 75% of emergence following which irrigation schedule was adopted according to the treatments.

Data recorded during 2021 revealed perceptible response of sugarcane growth to irrigation regimes and moisture management techniques. General mean of germination under various treatments was recorded 32.75% and there was no obvious difference in initial crop stand as influenced by different treatments. Biometric observations on plant growth and soil moisture have been recorded as per the technical programme. The crop is still in the field and observations on yield attributes and yield are yet to be recorded.

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

The field experiment was conducted during autumn season at *Kharika* Research farm, ICAR-Indian Institute of Sugarcane Research, Lucknow to enhance the crop productivity and profitability of autumn sugarcane planted in wide row spacing through high value intercrops without jeopardizing crop growth and development in sub-tropical India. The experiment comprising twelve treatment combinations was laid out in RBD design with three replications under three wide row spacings (90, 120, 150 cm) and three intercrops (maize, garlic and fenugreek). The sugarcane variety was Co 0238. The intercrops varieties were maize hybrid *Saurabh*, garlic-*Yamuna safed*, while fenugreek multi cut was USK 120. The soil of the experimental field was sandy loam (*Inceptisol*), non-saline in reaction (pH 8.37), low in organic carbon (0.44%) and available N (232.06 kg/ha), high in available P (39.8 kg/ha) and K (340.2 kg/ ha).

Results revealed (pooled 2 years) that in autumn sugarcane, number of millable cane (NMC) and sugarcane yield were significantly higher in 90 cm and 120 cm row spacing (NMC-86.48 thousand/ha, cane yield- 139.19 t/ha and 76.0 thousand/ha, 126.16 t/ha, respectively) in sugarcane sole crop (at par) as compared to 150 cm row spacing (66.94 thousand/ha, 114.05 t/ ha). Adopting wider row spacing of 150 cm and 120 cm reduced the mean cane yield (122.53 t/ha) by 5.8% and (126.49 t/ha) by 2.4%, respectively, as compared to 90 cm row spacing (129.53 t/ha). Among the intercropping system, the highest cane yield in 150 cm row spacing was found in sugarcane + maize (134.25 t/ha) followed by cane yield in 120 cm row spacing in sugarcane + fenugreek (133.11 t/ha) and sugarcane + garlic (129.20 t/ha) at 90 cm row spacing of intercropping system. Similarly, these treatments recorded significantly the highest growth characters as well as various yield attributing characters, however, were non-significant. The single cane weight was in the range of 1.2 to 2.3 kg, having tall cane length of 257 to 321 cm and average cane diameter of 2.44 to 3.0 cm. The internodes number

were higher (range of 22 to 33) and the internodes length in the range of 15.3 to 16.2 cm.

The high value intercrops significantly increased the total cane productivity (CEY) as well as total system gross and net returns as compared to sole crop of autumn sugarcane. Adopting sugarcane at 150 cm row spacing + maize (1:3 ratio) intercropping produced the highest cane equivalent yield (CEY 323.22 t/ha) followed by sugarcane at 120 cm row spacing + maize (1:2 ratio) intercropping the next best (CEY 297.36 t/ha). Sugarcane at 150 cm row spacing + maize (1:3 ratio) fetched the highest net income of ₹ 6,48,892/ha (B:C ratio of 3.36) followed by sugarcane at 120 cm row spacing + maize (1:2 ratio) with net income of ₹ 5,83,408/ha and sugarcane at 90 cm row spacing + maize (1:1 ratio) with net income of ₹ 4,86,729/ha. The next best intercrop treatment was sugarcane at 120 cm row spacing + garlic (1:5 ratio) with cane equivalent yield (CEY) of 285.27 t/ha and net income of ₹ 7,04,978/ha followed by sugarcane at 150 cm row spacing + garlic (1:7 ratio) with CEY 284.21 t/ha and net income of ₹ 6,90,096 /ha. Also, the highest benefit: cost ratio (3.74) was recorded with sugarcane at 120 cm row spacing + garlic (1:5 ratio) intercropping.

Sugarcane at 120 cm row spacing + fenugreek (1:3 ratio) the CEY 162.50 t/ha and net income of ₹ 3,68,272/ha (B:C ratio of 2.75). However from sole sugarcane at 90 cm row spacing, the CEY was 139.20 t/ha with net income of ₹ 2,76,091/ha (B:C ratio of 2.56) and in sole sugarcane at 120 cm row spacing, CEY was 126.20 t/ha with net income of ₹ 2,41,387/ha, while in sole sugarcane at 150 cm row spacing the CEY was 114.0 t/ha and net income of ₹ 2,06,153/ha only.

On the basis of results obtained for two years, it may be concluded that autumn sugarcane based intercropping system under wide row spacing with high value intercrops holds promise in increasing the net income of 2-3 times as compared to sole sugarcane and thus enhances the crop productivity and profitability in sub-tropical India.

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

A fixed field experiment was initiated from the month of June 2019 with the objective to identify the most remunerative sugarcane based cropping system in sub-tropical India. During *Rabi* season 2019-2020, four component crops (Wheat/ *Stevia*/ /Wild marigold/ autumn sugarcane) were evaluated as per treatments (Rice/*Tulsi/Kalmegh* – Wheat/*Stevia*/ wild marigold/ autumn sugarcane – Spring sugarcane plant – Sugarcane ratoon – *Mentha)* in the field condition. Plant crop was harvested during and left for raising of ratoon as succeeding crop in the field during summer season of 2021. Significantly the highest cane yield (90.0 t/ha) of plant sugarcane crop was recorded under Tulsi-Stevia - Sugarcane (Spring) - Sugarcane Ratoon-Mint cropping sequence as compared to cane yield (54.0 t/ha) in Rice-Wheat- Sugarcane (Spring) - Sugarcane Ratoon-Wheat cropping sequence during 2021-22.

Significantly the highest cane yield (90.0 t/ha) of plant sugarcane crop was recorded under *Tulsi-Stevia*-Spring sugarcane (plant) - Sugarcane ratoon-Mint cropping sequence as compared to cane yield (54.0 t/ha) in Rice-Wheat-Spring sugarcane plant - Sugarcane Ratoon-Wheat cropping sequence during 2021. Growth and yield attributes of succeeding sugarcane ratoon crop for 2021-22 in the sequence were recorded as per treatment.

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 the sustainable agriculture. Keeping above points in view, the sugarcane based Integrated farming system was planned and executed with objective to develop integrated farming system models for small farm holders.

Sugarcane based IFS developed and their results

(A) Autumn planted Sugarcane based IFS:

1. Sugarcane sole - gave ₹ 1,82,300/ha. net income
2. Sugarcane + Vegetables (Garlic, Fenugreek, Coriander, Tomato, Cauliflower, Spinach, Carrot, Fababean, Onion) fetched net income of ₹ 2,23,742.5/ha.
3. Sugarcane + Vegetables (Garlic, Fenugreek, Coriander, Tomato, Cauliflower, Spinach, Carrot, Fababean, Onion) + Horticultural Crop (Banana) + Backyard Poultry (Breed-*Asheel, Nirbheek, Kadaknath*) + Dairy unit (Breed-*Sahiwal*) fetched net income of ₹ 3,07,402.5 / ha.
4. Sugarcane + Vegetables (Garlic, Fenugreek, Coriander, Tomato, Cauliflower, Spinach, Carrot, Fababean, Onion) + Horticultural Crop (*Karonda* boundary plantation) +Backyard

Poultry (Breed, *Asheel, Nirbheek, Kadaknath*) + Fisheries *(Rohu, Catla, Nain)* + Vermicompost (*Erucina fotida*) + Apiculture + Mushroom fetched net income of ₹ 4,48,202.5/ha.

The results clearly indicated that autumn sugarcane based integrated farming system as Sugarcane + Vegetables (Garlic, Fenugreek, Coriander, Tomato, Cauliflower, Spinach, Carrot, Fababean, Onion, Brinjal, Green chilli, Cabbage, Pea, Soya, Sauf, Bottle guard, Okra, Cowpea, Cucurbit, Maize) + Horticultural Crop (*Karonda* boundary plantation + Papaya + Banana) + Backyard Poultry (Breed, *Asheel, Nirbheek, Kadaknath,* Quail) + Dairy unit (Breed- *Sahiwal*) + Fisheries (*Rohu, Catla, Nain*) + Vermicompost (*Erucina fotida*)+ Apiculture + Mushroom fetched net income of ₹ 4,48,202.5/ha and fetched additional income of ₹ 2,65,902.5/ha (Table 2.11).

(B) Spring planted sugarcane based IFS:

1. Sugarcane sole - ₹ 1,67,350/ha
2. Sugarcane + Vegetables (Bottle gourd, Sponge gourd, Tomato, Brinjal, Pumpkin, Onion,) fetched net income of ₹ 2,21,040/ha.
3. Sugarcane + Vegetables (Bottle gourd, Sponge gourd Tomato, Brinjal, Pumpkin, Onion) + Horticultural Crop (Banana) + Backyard Poultry (Breed- *Asheel, Nirbheek, Kadaknath,* Quail) fetched net income of ₹ 2,89,570/ha.
4. Sugarcane + Vegetables (Bottle gourd, Sponge gourd, Tomato, Brinjal, Pumpkin, Onion) + Horticultural Crop (Banana) + Backyard Poultry (Breed- *Asheel, Nirbheek, Kadaknath,* Quail) + Fisheries *(Rohu, Catla, Nain)* + Vermicompost (*Erucina fotida*) + Apiculture + Mushroom fetched net income of ₹ 4,30,370/ha.

The results clearly indicated that spring sugarcane based integrated farming system as Sugarcane + Vegetables (Bottle gourd, Sponge gourd, Tomato, Brinjal, Pumpkin, Onion, Maize Fenugreek, Pachoi, Chinese gobhi) + Horticultural Crop (Banana, *Karonda,* Papaya) + Backyard Poultry (Breed- *Asheel, Nirbheek, Kadaknath,* Quail) + Dairy Unit (Sahiwal) + Fisheries *(Rohu, Catla, Nain)* + Vermicompost (*Erucina fotida*) + Apiculture + Mushroom fetched net income of ₹ 4,30,370/ha by fetching additional income of ₹ 2,63,020/ha (Table 2.12).

Table 2.11. Productivity and profitability of different components of the cropping/farming system integrated with sugarcane (autumn planted sugarcane) during 2021-22

Sr. No.	Cropping/Farming system	Cost of production (₹/ha)	Gross income (₹/ha)	Net income (₹/ha)	Income from component crop/ enterprise (₹/ha) or enterprises /unit	B:C ratio
1.	Sugarcane (Sole) CoPk 05191	1,66,200	3,48,500	1,82,300	-	2.09
2.	Sugarcane + Vegetables (including horti. crops) throughout year	1,84,800	4,08,542.5	2,23,742.5	41,442.5	2.21
3.	Sugarcane + Vegetables (including horti. crops) throughout year + Backyard poultry + Dairy unit.	2,11,650	5,19,052.5	3,07,402.5	83,660	2.45
4.	Sugarcane + Vegetables throughout year (including horti. crops) + Backyard poultry + Dairy unit + Fisheries + Vermicompost + Apiculture + Mushroom	2,22,100	6,70,302.5	4,48,202.5	1,40,800	3.01
	Additional income from no. 4 S-IFS modal ₹ 2,65,902/ha.					

Table 2.12. Productivity and profitability of different components of the cropping/farming system integrated with spring planted sugarcane-2021-22

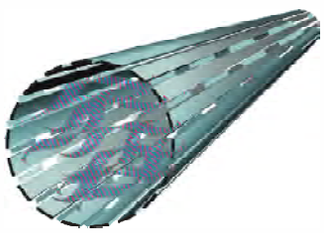
Sr No.	Cropping/Farming system	Cost of production (₹/ha)	Gross income (₹/ha)	Net income (₹/ha)	Income from component crop/ enterprise (₹/ha) or enterprises/ unit	B:C ratio
1.	Sugarcane (Sole) CoPk 05191	1,68,400	3,35,750	1,67,350	-	1.99
2.	Sugarcane + Vegetables (including horti. crops) throughout year	1,80,900	4,01,940	2,21,040	53,690	2.22
3.	Sugarcane + Vegetables (including horti. crops) throughout year + Backyard poultry + Dairy unit.	2,05,900	4,95,470	2,89,570	68,530	2.40
4.	Sugarcane + Vegetables throughout year (including horti. crops) + Backyard poultry + Dairy unit + Fisheries + Vermicompost + Apiculture + Mushroom.	2,16,350	6,46,720	4,30,370	2,89,570	2.98
	Additional income from no. 4 S-IFS model- ₹ 2,63,020 /ha					

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

A stable cellulose aerogel has been prepared by grafting porous silica on the surface by *in situ* hydrolysis. This aerogel shows ~ 70 % more absorption capacity in the 5th cycle. Further in urea release kinetics, the aerogel shows < 1/3 and 3/4 of urea release from naked porous silica and cellulose, respectively, in acidic condition, which qualifies to be a sustainable fertilizer reservoir in acid soil.

Hydrophobic coating for slow release of fertilizer

The major bottleneck in case of conventional water-soluble nitrogen fertilizer is its leaching and run-off loss which will lead to reduced nutrient use efficiency. So, there is a need for smart fertilizer with controlled slow release. It can easily be achieved by hydrophobic coating with organic and inorganic polymers sourced from petroleum-based. Here, in this present work, mesoporous silica along with a binding agent used for slow release of water-soluble fertilizer. The hydrophobic mechanically stable coating composite was chemically and structurally characterized by XRD, FTIR and TEM. Rotary drum method was used to obtain different thickness of coated urea pellets. The release behaviour and growth efficiency studies were carried out in rice plant (variety: PB 1637). The coated urea pellet with 50% of standard recommended dose showing a ~ 70% yield increase along with an enhanced physiological parameters like photosynthesis, transpiration and stomatal conductance at its vegetative stage. This hydrophobic, mechanically stable and economically friendly coating composite have a sustained nitrogen release with improved fertilizer efficiency and enhanced crop yield and physiological parameters.



Schematic showing the porous silica tube on the urea loaded cellulose fibers

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

This project was initiated with the objectives of preparing sugarcane production system responsive technology matrix, evolving sugarcane grower-led extension model for accelerated adoption of sugarcane technologies, exploring possibilities of institutional arrangement for technology management at village level and impact assessment and constraints in diffusion of sugarcane technologies and providing feedback for development of further need based technologies.

The decision support was invoked, based on preferential choices, among sugarcane stakeholders involving researchers from ICAR-IISR, Lucknow, authorities of Sugar Mill, Kumbhi (Cane advisor, GM Cane, Sr. Manager Cane) and Sugarcane growers for introducing three best preferred sugarcane varieties of early category evolved by ICAR-IISR, Lucknow *i.e.*, CoLk 11203, CoLk 14201 and CoLk 94184. The data analyzed for six on- farm trials, two of each variety planted in autumn at sugarcane growers fields in Patna and Majhia villages in Kumbhi Chini Mill, Kumbhi Reserve Zone revealed that performance of varieties in respect of millable cane and diameter was found the highest in variety CoLk 14201 (1,00,000/ha) as well as diameter of cane (2.55 cm), respectively, followed by CoLk 94184 millable cane (95,000/ha) and diameter (2.55 cm) and CoLk 11203 millable cane (93,000/ha) and diameter (2.50 cm) (Table 2.13). With regards to visual appearance of the sugarcane variety, CoLk 11203 shown lodging tendency to some extent, no lodging in variety CoLk 14201 small internodes which were found with increased length in well irrigated condition. In case of variety CoLk 94184, there was no lodging tendency and good for near to jungle due to hardness. The lab analysis of qualitative characters such as brix, POL, recovery %, extraction, POL% cane and losses was carried out at sugar mill facility. The highest recovery was registered in CoLk 14201 (11.8 %). The same variety was also found best in extraction (50%), POL in cane (14.3%) and POL in juice (20.34%). Among all the varieties, performance of CoLk 11206 was found the best in Lakhimpur Kheri area from seed distributed by ICAR-IISR (Table 2.14).

Collaborative Project: ICAR-CAZRI, Jodhpur: Efficacy and evaluation of potassic organo mineral fertilizer (OMF)

The field trial to assess the potassic organo-mineral fertilizer (OMF) in sugarcane crop was conducted during spring- 2020. The OMF contains 10% K using feldspar, developed by ICAR-CAZRI, Jodhpur. Potassium release from it is gradual and may be beneficial for its K utilization over the crop growth period of sugarcane crop. The experiment comprised ten treatments in different combinations of MOP, OMF, and FYM with 50 and 75% recommended potash levels were designed in randomized block design with three replications.The trial was laid out and planted sugarcane crop (*cv.* CoLk 09204) on 23rd February 2020. Potassium through muriate of potash (MOP) registered higher cane diameter (2.63 cm), NMC (102.2 thousand/ha), single cane weight (1.22 kg), higher LAI (7.43) and maximum photosynthetic rate (14.91 µmol $^{m-2s-1}$) resulted

Table 2.13. Performance of sugarcane varieties at sugarcane growers' field

Variety	No. of on -farm trial	Germination (%)	No. of tillers per hectare	No. of millable canes per hectare	Average height (cm)	Average diameter (cm)
CoLk 11203	2	70.00	112500	93000	213.00	2.50
CoLk 14201	2	77.50	120500	100000	217.00	2.55
CoLk 94184	2	74.40	116000	95500	208.50	2.52

Table 2.14. Varietal lab analysis of CoLk series variety of early group

Variety	Crop	Avg. Brix	Avg. pol	Avg. recovery	Avg. extraction	Avg. pol % cane
CoLk 11206	Plant	20.53	18.63	10.30	43.19	12.80
CoLk 09204	Plant	19.53	17.43	10.22	46.66	12.72
CoLk 14201	Plant	21.84	20.34	11.80	50.07	14.30

in significantly the highest cane yield (105.1 t/ha), closely followed by OMF (99.7 t/ha) at 100% of recommended K. Significantly cane yield increased with increasing potassium level being at par with 75 and 100% of K level. K through MOP recorded higher cane and sugar yield being at par with OMF at 50, 75 and 100% of the recommended potassium level. MOP increased the cane yield ranged from 2.0-7.0% compared to OMF under different levels of K. However, and the difference was found non-significant. The lowest cane yield and attributes was noticed in absolute control (79.57 t/ha). Potassium application either through MOP or OMF improved the cane and sugar yield compared to alone nutrient application of N& P. Results revealed that K application through potassic organo-mineral fertilizer (OMF) improved cane yield and quality appeared to be an alternative source of K without any detrimental effect on yield.

AICRP on STCR: Soil test and resource-based integrated plant nutrient supply system for sustainable sugarcane production

Targeted yield equations of spring season ratoon crop (var. CoLk 09204) was developed during 2020-21 which is useful for recommendation of mineral fertilizers based on soil test values and getting fixed target in the alluvial soils of sub-tropical condition of India. The basic data and targeted yield equations for the plant crop was vivid in Table 2.15. The nutrient requirement of N, P and K were 1.84, 0.52 and 2.35 for the production of per tonne cane yield (var. CoLk 09204), respectively. The

Table 2.15. Basic data and targeted yield equation during 2020-21

Basic data	N	P	K	Targeted yield equations
Nutrient requirement (kg/tonne)	1.84	0.52	2.35	FN= 4.53T−1.14 STVN− 0.28ON
Soil efficiency (%)	46.2	174.7	71.7	FP = 0.86T−2.91
Fertilizer efficiency (%)	40.7	60.1	161.6	STVN− 0.07OP
Organic efficiency (%)	11.5	4.07	14.0	FK= 1.45T−0.44 STVN− 0.09OK

soil efficiency was 46.2, 174.7 and 71.7% N, P and K whereas fertilizers efficiency was 40.7, 60.1 and 161.6, respectively. The organic efficiency was 11.5, 4.07 and 14.0% N, P and K, respectively.

Contract Research Project: Evaluation of bio efficacy and phytotoxicity of pre-emergent application of two herbicide products BAS 781 02 H and BAS 822 01 H against weeds in sugarcane and its effect on succeeding crop

A field experiment on Evaluation of bio efficacy and phytotoxicity of pre-emergent application of two herbicide products BAS 781 02 H and BAS 822 01 H against weeds in sugarcane and its effect on succeeding crop with objective to develop an economic and effective pre-emergence herbicide for control of broad-spectrum weeds in sugarcane. The weed control efficiency of both the herbicides (BAS 781 02 H and BAS 822 01 H) were found better in plant crop of sugarcane over control plot at both the locations (Lucknow and Pravaranagar). There was no phytotoxicity symptoms recorded in sugarcane plant crops at the both the locations. The succeeding crop in the field was not affected by the residual effect of both the herbicides in the field condition at both the locations.

Contract research project: Irrigation water saving in sugarcane through application of super absorbent under field condition

The experiment under contract project has been conducted at ICAR-IISR farm with four IW/CPE ratio (0.4, 0.6, 0.8, 1.0) and ZEBA absorbent application with four treatments (one time application at planting, one time application at first hoeing, Application in two equal splits-planting + earthing up, control-no ZEBA application) in sugarcane variety CoPk 05191. The data recorded on tillering, NMC, cane length, cane diameter and cane yield indicated significant variations among the treatments during the spring, 2020. Numerically the highest values of above parameters were recorded under the effect of IW/CPE ratio 1.0 + Application of ZEBA absorbent in two equal splits-planting + earthing-up closely followed by IW/CPE ratio 1.0 + Application of ZEBA absorbent at first hoeing whereas the lowest values were associated with IW/CPE ratio 0.4 + No application of ZEBA absorbent. Number of tillers (000/ha) ranged from 158-186 and 142-173, cane length (cm) ranged from 258-289 and 246-275, NMC (000/ha)

ranged from 117-133, cane diameter (mm) ranged from 23.8-31.20. The cane yield (t/ha) varied from 65.50-86.60. On the basis of overall performance of the crop, IW/CPE ratio 1.0 + Application of ZEBA absorbent in two equal splits-planting + earthing-up revealed the best results (86.60 t/ha cane yield) among all the other treatment combinations.

Sustaining sugarcane yield under multiple ratooning through drip irrigation

The experiment was initiated from 4th ratoon. This year, 9th ratoon crop was initiated in the first week of February 2020 after stubble shaving and interculturing. The crop is being drip irrigated daily and fertigation was done weekly. Recommended dose of fertilizer *i.e.* 200 kg N, 60 kg P_2O_5 and 60 kg K was applied through fertigation in 20 equal doses. Irrigation water was kept equal to pan evaporation. Drip irrigation treatments were provided with irrigation water equal to 0.6 times the pan evaporation, considering 60% surface area of field is wet. Surface treatments were irrigated at IW/CPE ratio equal to 1 and depth of irrigation water was kept at 80 mm. The highest sugarcane yield (47.36 t/ha) was recorded in drip irrigated crop when planting was done in paired row planting at 45×135×45 cm (Table 2.16). The lowest sugarcane yield (35.06 t/ha) was recorded in surface irrigated crop planted at 90 cm spacing. The highest irrigation water use efficiency (1020.6 kg/ha-cm) was recorded in drip irrigated crop, planted in paired row planting at 45×135×45 cm (Table 2.17). The lowest irrigation water use efficiency (438.3 kg/ha-cm) was recorded in surface irrigated crop planted at 90 cm spacing.

ICAR funded Agri-consortia research programme on water

To conduct this experiment, eight sugarcane varieties from early maturing group (CoPk 05191, CoLk 14201, CoS 13231, Co 0238, CoS 08272, CoLk 94184, UP 05125, Co 0118) and eight from mid late maturing group (CoS 09232, Co 05011, CoS 12232, CoLk 09204, CoLk 14203, CoS 08276, CoS 97261, CoSe 11453) were planted in mid of February, 2020 and harvested in February, 2021. It was planned to irrigate the crop with four

Table 2.16. Effect of irrigation treatments on sugarcane yield

Irrigation/Planting treatment	Plant	Average for first to eighth ratoon	Ninth ratoon
T2: Planting at 75 cm row to row and at alternate row drip irrigation-fertigation	74.37	74.93	47.00
T3: Paired row planting at 40×110×40 cm with drip irrigation-fertigation	81.62	73.33	39.43
T4: Paired row planting at 45×135×45 cm with drip irrigation-fertigation	71.68	69.00	47.36
T5: Paired row planting at 60×120×60 cm with drip irrigation-fertigation	82.40	74.09	43.99
T6: Paired row planting at 40×110×40 cm with sub-surface drip irrigation-fertigation	80.48	72.11	45.44
T7: Surface drip in ring-pit planting method (105×75 cm) with drip irrigation-fertigation	88.78	84.94	46.62
Average for drip	79.89	74.73	44.97
T1: Planting at 75 cm row to row distance with surface irrigation and recommended fertilizers application in soil	65.29	51.65	36.30
T8: Planting at 90 cm row to row distance with surface irrigation and recommended fertilizers application in soil	67.09	50.23	35.06
Average for surface	66.19	50.94	35.68
SE±	1.44		1.47
CD (P=0.05)	2.53		2.58

Table 2.17. Effect of irrigation treatments on irrigation water use efficiency

Irrigation/Planting treatment	Plant	Average for first to eighth ratoon	Ninth ratoon
T2: Planting at 75 cm row to row and at alternate row drip irrigation-fertigation	1106.7	1501.3	1013.0
T3: Paired row planting at 40×110×40 cm with drip irrigation-fertigation	1214.6	1439.1	849.8
T4: Paired row planting at 45×135×45 cm with drip irrigation-fertigation	1066.6	1366.3	1020.6
T5: Paired row planting at 60×120×60 cm with drip irrigation-fertigation	1226.1	1464.2	948.1
T6: Paired row planting at 40×110×40 cm with sub-surface drip irrigation-fertigation	1197.7	1416.5	979.2
T7: Surface drip in ring-pit planting method (105×75cm) with drip irrigation-fertigation	1321.2	1701.7	1004.8
Average for drip	1188.8	1481.5	969.3
T1: Planting at 75 cm row to row distance with surface irrigation and recommended fertilizers application in soil	583.0	624.3	453.8
T8: Planting at 90 cm row to row distance with surface irrigation and recommended fertilizers application in soil	599.0	592.5	438.3
Average for surface	591.0	608.4	446.0
SE±	17.8		29.2
CD (P=0.05)	31.4		51.4

irrigation treatments at 60% depletion of available soil moisture and with the following quantity of irrigation water:

I1 = 60% of crop water requirement

I2 = 80% of crop water requirement

I3 = 100% of crop water requirement

I4 = 120% of crop water requirement

Due to lock-down because of Covid-19 outbreak, irrigation treatments could not be imposed. All the varieties were provided with three pre-monsoon irrigations with 80 mm depth of water.

Data on quantity of irrigation water applied, number of millable canes, sugarcane yield, sucrose % juice, brix and purity % juice were recorded. Sugarcane varieties behaved differently in all these parameters. In early maturing varieties, the highest number of millable canes (140.93 thousand) were recorded in CoLk 94184 followed by CoPK 05191 (119.95 thousand), whereas the lowest number of millable canes (69.82 thousand) were recorded in Co 0118 (Fig. 2.7). In early maturing varieties, the highest sugarcane yield was recorded for sugarcane variety CoPK 05191 (109.86 t/ha) followed by CoLk 94184 (83.227 t/ha) (Fig. 2.8). The yield difference among sugarcane varieties CoLk 14201, CoS 13231 and CoS 08272 was observed to be non-significant. These varieties yielded around 65 t/ha. The lowest sugarcane yield (48.34 t/ha) was observed for sugarcane variety Co 0118. Irrigation water use efficiency (IWUE) was the highest (4577.5 kg/ha-cm) for CoPK 05191 followed by CoLk 94184 (3467.8 kg/ha-cm), the lowest IWUE (2014.1 kg/ha-cm) was recorded in Co 0118. The difference in irrigation water use efficiency among sugarcane varieties CoLk 14201, CoS 13231 and CoS 08272 was observed to be non-significant. The difference between brix and sucrose content of juice from different sugarcane varieties was not significant (Fig. 2.10). The highest sucrose content in juice (17.13%) was found in CoLk 14201 variety followed by Co 0118 (17.10%). The lowest sucrose content (15.96%) was recorded in sugarcane variety CoS 08272. Juice purity was the highest (85.23%) for sugarcane variety CoS 13231 followed by Co 0118 (85.09%). The lowest juice purity (83.75%) was observed in sugarcane variety CoS 08272.

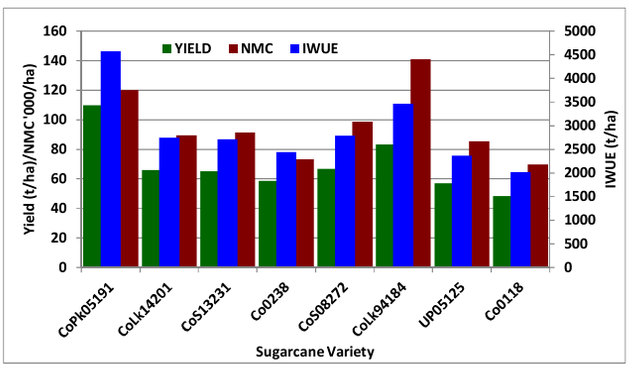


Fig. 2.7. Yield, number of millable canes and irrigation water use efficiency of early maturing varieties

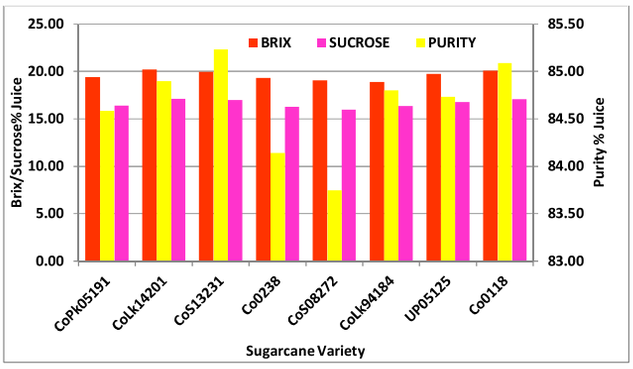


Fig. 2.8. Juice quality parameters of early maturing varieties

In mid-late maturing varieties, the highest number of millable canes (106.42 thousand) were recorded in CoS 97261 followed by CoLk 09204 (105.96 thousand), whereas the lowest number of millable canes (67.15 thousand) were recorded in Co 05011 (Fig. 2.9). In mid-late maturing varieties, the highest sugarcane yield was recorded for sugarcane variety CoLk 09204 (92.52 t/ha) followed by CoLk 14203 (73.56 t/ha). The yield difference among sugarcane varieties CoS 08276, CoS 97261 and CoSe 11453 was observed to be non-significant. These varieties yielded around 65 t/ha. The lowest sugarcane yield (34.13 t/ha) was observed for sugarcane variety Co 05011. Irrigation water use efficiency (IWUE) was the highest (3855.0 kg/ha-cm) for CoLk 09204 followed by CoLk 14203 (3065.0 kg/ha-cm), the lowest IWUE (1421.9 kg/ha-cm) was recorded in Co 05011. The difference in irrigation water use efficiency among sugarcane varieties CoS 08276, CoS 97261 and CoSe 11453 was observed to be non-significant. The difference between brix and sucrose content of juice from different sugarcane varieties was not significant (Fig. 2.10). The highest sucrose content

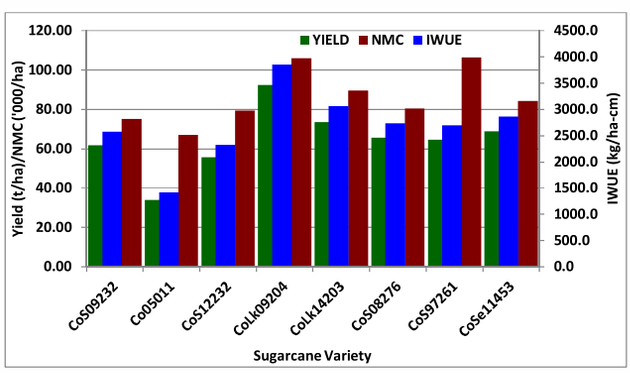


Fig. 2.9. Yield, number of millable canes and irrigation water use efficiency of mid-late maturing varieties

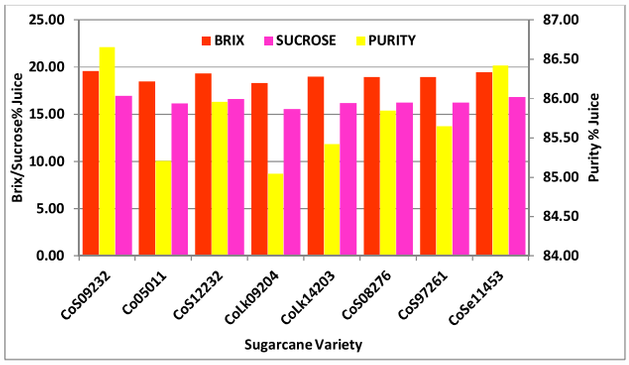


Fig. 2.10. Juice quality parameters of mid-late maturing varieties

in juice (16.98%) was found in CoS 09232 variety followed by CoSe 11453 (19.47%). The lowest sucrose content (15.56%) was recorded in sugarcane variety CoLk 09204. Juice purity was highest (86.66%) for sugarcane variety CoSe 09232 followed by CoSe 11453 (86.42%). The lowest juice purity (85.05%) was observed in sugarcane variety CoLk 09204.

In general, sugarcane juice brix and sucrose content of early maturing variety group was higher than the mid-late maturing variety group.

Technology developed

1. A density of 2.0 *Ipomoea* sp./m^2 may be considered as an economic threshold level of *Ipomoea* infestation, beyond which an effective weed control measure is essential for enhancing NMC, single cane parameters and cane yield of sugarcane.
2. Under heavy infestation of *Ipomoea* sp. in sugarcane, the reduction in yield could be minimised by replacing the sugarcane varieties with Co 12027, CoLk 11206, CoPant 14222 and CoPb 14182, respectively.

CHAPTER 3

Management of Insect Pests and Diseases

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

During the period, visits in command area of DSCL group; Balrampur Chini Mill Group; Bajaj Hindusthan Group; Seksaria Biswan Chini Mill, Biswan; Simbhaoli Sugar Mills, Chilwariya; KM Sugar Mills, Masaodha, Faizabad; Triveni Sugar Mill, Kushinagar and United Province Sugar Co. Ltd., Kushinagar. were made to survey for occurrence of sugarcane insect pests and diseases on commercially cultivated varieties of cane in Uttar Pradesh. Incidence of red rot was noticed in Co 0238, Duplicate CoLk 94184/unknown variety, CoS 8436, CoS 91269, CoS 767 and CoJ 85. Localized incidence of red rot was also noticed in another popular early sugarcane variety Co 0118 at two locations in the mixture crop with Co 0238 (Biswan, Sitapur and Basti). In general, incidence of red rot was very high (50-90%) in the variety Co 0238. However, in some fields, the incidence was to tune of 20 per cent with the variety CoLk 8102, Duplicate CoLk 94184 and CoS 8436. Severe incidence of smut was observed in CoSe 92423 (10-20%) and Co 0238 (15-35%). Incidence of GSD was noticed in most of the field surveyed (1-4%) with the varieties CoLk 94184, Co 98014, Co 89029, CoS 91269 and CoLk 9709. In some locations, higher incidence of GSD was noticed in CoLk 94184 (5-10%). Incidence of the minor diseases like Pokkah boeng is increasing substantially and it is mostly affecting the early sugarcane variety Co 0238 to the tune of 15 to 40%. Stray incidence of leaf scald was also observed in Co 0238.

Survey of command area of Govind Sugar Mill, Aira, Lakhimpur Kheri disclosed that about 25-30% cane area was dried due to water logging (heavy rainfall occurred in the month of June) in all surveyed villages (Sarsawan, Guplaria, Basaia, Khanipur). Sporadic incidence (1-5%) of top borer, stalk borer, *Pyrilla* and Pokkah boeng was observed in certain locations in variety Co 0238. The incidence (in traces1-2%) of GSD, smut and Pokkah boeng was also observed in variety Co 0238 in some fields (Fig. 3.1).

Fig. 3.1. Photographs of insect pests and diseases, crop damages from the North West Zone of sugarcane growing areas

During survey in command area of DCM Sugar, Rupapur (Hardoi), incidence of top borer (15% Vth brood), stalk borer, (5%), web mite (5-6%) and white fly (4-5%) was observed at certain locations in variety Co 0238. However, incidence of YLD, ring spot, eye spot, red leaf spot was in tune of 1-2% whereas red rot and wilt incidence (50-60%) was recorded in plant as well as ratoon crop of Co 0238 in two different fields.

In the survey conducted in command areas of sugar mills of DSCL, Rupapur; Balrampur Chini Mill, Maizapur; Avadh Sugar and Energy Ltd., Hargaon, Sitapur; Govind Sugar Mill, Aira, Lakhimpur Kheri) and Madhya Pradesh (Mekalsuta Sugar Mill, Barwani and Maarawe Sugar Private Ltd, Dhar), incidence of fifth brood of top borer (15%), stalk borer, (5%), web mite (5-6%) and white fly (4-5%) was observed in variety Co 0238. Sporadic incidence of stalk borer top borer, *Pyrilla* and Pokkah boeng was also observed. Severe incidence of root borer (50-60%) was observed in command areas of Avadh Sugar and Energy Ltd., Hargaon, Sitapur. Incidence of smut (50-90%) was reported in ratoon crops of CoVSI 8005 along with white fly in Mekalsuta Sugar Mill, Barwani.

In Bihar, command areas of Vishnu Sugar Mills Ltd., Gopalganj; Sasa Musa Sugar Works Ltd., Sasa Musa; Magadh Sugar and Energy Ltd., Sidhwalia; Harinagar Sugars, Harinagar; Narkatiyaganj Sugar Mill and HPCL, Sugauli were monitored. Incidence of red rot was observed in most of the area in the variety Co 0238 ranging from 50 to 70%. Pokkah boeng was also noticed up to 20% with the variety Co 0238 in most of the locations. Incidence of red rot (2-5%), smut (1-3%), YLD (3-10%) and GSD (1-3%) were noticed with the variety CoSe 1423. The incidence of wilt was observed 2 to 5% in the variety Co 0118 and BO 154 at few locations and yellow leaf disease (YLD) was noticed in varieties *viz*., CoSe 95422, CoP 06436, CoLk 94184, Co 0118, BO 130 and Co 0238. Sporadic incidence of smut, pokkah boeng GSD, YLD, Leaf Scald were also observed in the other varieties in most of the locations surveyed. The concomitant propagation of sugarcane disease GSD was noticed in most of the varieties of sugarcane at several locations which will be alarming in future.

Surveys were conducted in the command areas of Pravara, Kolpewadi, Sanjeevani, Ashok, Sangmner and Rahuri Cooperative Sugar Mills of Ahmednagar district (Maharashtra) for the seasonal prevalence of diseases and pests in the tropical sugarcane fields. Major area of the sugarcane was under CoM 265 (80%) and only 10%

to 15% area was under Co 86032 variety. The major incidences of disease *viz*., brown spot, rust and pokkah boeng were observed to be in the range of 60% to 97%, 50% to 85% and 21% to 30%, respectively in the surveyed sugarcane fields. The incidence of yellow leaf disease (YLD) was monitored from 20% to 35% in CoM 265 and VSI 8005 varieties and a minor incidence of sugarcane leaf scorch (10% to 20%) was also reported in both the varieties. Among the insect pest infestations, white grub was observed to be in sporadic areas causing damage in the range of 40% to 80%, whitefly infestation was observed in the range of 25% to 75%, however, the infestations of woolly aphid, *Pyrilla*, internode and early shoot borer was reported in the range of 20% to 40% and minor infestations of top borer and root borer were also reported in the surveyed sugarcane fields (Fig. 3.2).

Fig. 3.2. Photographs of insect pests and diseases, crop damages reported during survey 2021 from sub-tropical sugarcane growing areas

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

Evaluation of different anti-protozoan chemicals against termites

Different anti-protozoan chemicals *viz*., Metronidazole; Albendozole; Ornidazole; Tinidazole; Nitazoxanide were evaluated for their bio-efficacy against termites reared on artificial diet under laboratory condition. Amongst these, 100 per cent mortality of termites was recorded in 11 days in the treatment of Ornidazole and Tinidazole, while it was in 14, 17 and 24 days in case of Metronidazole, Nitazoxanide and Albendozole, respectively. Termites could survive up to 52 days in untreated control. The mortality amongst the termite population is attributed to the possible gut defaunation, which ultimately resulted in to failure in digestion of cellulose by the termites.

Metagenomic analysis of the whole gut microbiota in termite species *Odontotermes* infesting sugarcane

Taxonomic and functional metagenomic analysis of the whole gut microbiota of the termite species *Odontotermes obesus*, was carried out. Of the 4,34,089 assembled scaffolds (assembly size, 40,44,22,708 bp; average size, 931.7 bp; N_{50}, 1004 bp); 6,91,170 genes were predicted, with an average gene length of 518 bp. Bacteroidetes and Proteobacteria were the two most predominant phylum present in the gut with *Treponema* and *Pseudomonas* being the dominant bacterial genus. Two species of the spirochete bacteria *Treponema viz. T. azotonutricium* and *T. primitia* were identified as the most prevalent bacterial species in termite gut. The metagenomic analysis also revealed the presence of four protozoan species *viz. Metadevescovina cuspidate, Pyrsonympha grandis, Spirotrichonympha leidyi* and *Trichonympha* sp. in termite gut along with several bacterial endosymbionts (*Candidatus* Ancillula trichonymphae, *Candidatus* Azobacteroides pseudotrichonymphae, *Candidatus* Desulfovibrio trichonymphae, *Candidatus* Endomicrobium trichonymphae) associated with termite gut protozoans. It has been reported by previous workers also those higher termites like *O. obesus*rely on/or harbour a mutualistic hindgut microbiome exclusively constituted by prokaryotes (bacteria), especially spirochetes, for lignocellulose decomposition.

The functional capacities of the microbial communities present in the termite gut were also assessed using COGNIZER (v0.9b). Functional classification using the COG database distributed genes into 20 major functional categories *viz*., general function (5.4%), amino acid transport and metabolism (4%), energy production and conversion (3.0%), carbohydrate transport and metabolism (4.3%), lipid transport and metabolism (4.3%) and transcription (6%), among others. Ontology analysis based on the KEGG database distributed genes into six major functional categories with. metabolism (21%), environmental information processing (6%), cellular processes (3%) and genetic information processing (5%) being the major categories (Fig. 3.3). Further detailed studies on functional analysis are underway.

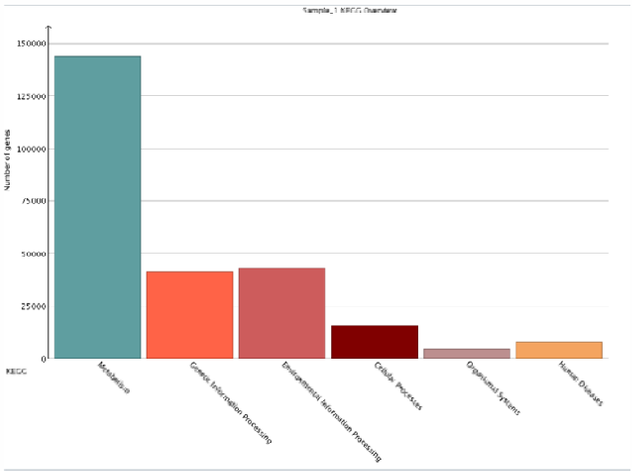


Fig. 3.3. KEGG functional category hits distribution of termite gut microbiome

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

Pupae of stalk borer and top borer were collected and kept at ambient temperature in wide mouth glass tubes to avoid mating after emergence of moths. Two methods were used for extracting semiochemicals from virgin females. In first method, hundred virgin female moths were released into the THF cutter and female scent was collected in 150 ml Methanol AR Grade (solvent). In second method, abdomen tips from 7th segments of virgin females were clipped off in to solvent (Methanol AR Grade) shake on rotary shaker for 150 minutes. Extracts were concentrated in rotary evaporator. Concentrates collected were stored at 5°C in refrigerator.

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

Immediately after release, male moths showed no attraction. However, activity was noticed after 15 minutes of release. Cumulative attraction of male moths of top borer (72%) and stalk borer (56%) was higher in extractions obtained by first method (Table 3.1).

Evaluation of essential oils against black bug of sugarcane

For the evaluation of toxic effect, essential oils (Eucalyptus, Lemon grass, Bottle brush, *Lantana camera*, Lemon leaves) on black bug, *Dimorphpterus gibbus* (lab culture), essential oil was extracted by steam distillation method (50°C). The amount of essential oil obtained per 100 gm leaves of Eucalyptus, Lemon grass, Bottle brush, *Lantana camera*, Lemon leaves was 1.25, 0.5, 0.8, 0.2, 0.9 ml, respectively. There was total five treatments and one untreated control was replicated thrice. In each replication, 0.5 µl essential oil on 1 cm^2 piece of whatman filter paper was dropped and treated paper was released to each petri dish containing 10 bugs. Plates were kept at 27°C and 70±5% RH in BOD. Observations were recorded 24 hours after release and up to 80.0 per cent mortality was observed in eucalyptus, *Lantana* and bottle brush and there was no bug mortality in other treatments.

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

Effect of various diets on the parasitizing efficiency of *Trichogramma chilonis* Ishii (sugarcane adapted top borer strain)

Adults of *T. chilonis* (collected from egg masses of top borer) were fed on nectar and flower solution of various flowers *viz*., hibiscus (red and white), red rose, lilly, ixora, lantana, honey water, sugar –water along with control (no food). Effect of these diets was tested on development duration and parasitizing efficiency of the strain. Experiment was conducted in laboratory conditions at 28±2°C and 60±5% RH. Development period from egg to adult varied from 7.2-8.2 days depending on diet. The higher fecundity was observed

Table 3.1. Number of male moth attracted by semiochemical extracted from female moths of top borer and stalk borer

Treatments	Just after release of moths	15 minutes after release of moths	30 minutes after release of moths	45 minutes after release of moths	60 minutes after release of moths	24 hours after release of moths	Total moths attracted
Top Borer							
Extracted by method 1	0	7	4	15	4	6	36/50
Extracted by method 2	0	7	3	13	3	7	31/50
Stalk Borer							
Extracted by method 1	0	6	3	10	3	6	28/50
Extracted by method 2	0	6	2	9	4	5	26/50

in flower solutions of lilly, orange lantana and red hibiscus (40.2-49.0) (Fig. 3.4). Honey-water solution and ixora flower solutions as a food source yielded maximum adult progeny (153.1-179.2%). Higher female progeny (>70%) was observed in all nutrition regimes except red rose flower.

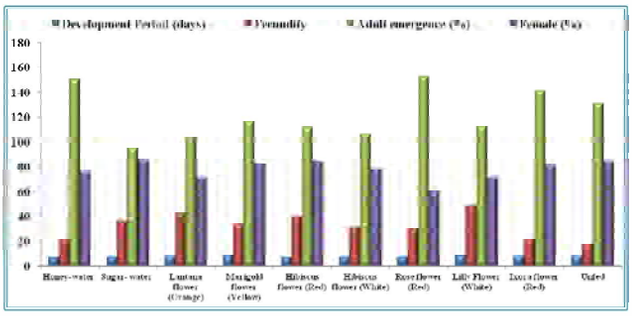


Fig. 3.4. Adult nutrition effect on the parasitizing efficiency of *Trichogramma chilonis* Ishii (sugarcane adapted top borer strain)

Reproductive potential of *Tetrastichus howardi* reared on larvae and pupae of sugarcane borers

Tetrastichus howardi was reared on larva and pupa of pink borer, internode borer, top borer. Development period was completed within 16-17 days. Mean number of progeny per pupa (123.4 to 126.0) was higher compared to progeny per larva (84.0 - 108.8) (Fig. 3.5). Maximum number of progenies was recorded on pink borer and minimum on top and internode borer. Maximum females emerged from pink borer larva (96.9%) followed by top borer and internode borer. Sex ratio (Male: Female) varied in larva (21.8 -31.7) and pupa (20.5- 26.9) depending on host.

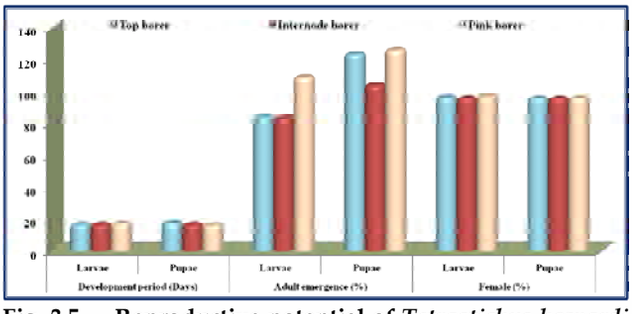


Fig. 3.5. Reproductive potential of *Tetrastichus howardi* on larvae and pupae of sugarcane borers

Dispersal ability of *Tetrastichus howardi* in sugarcane field

Parasitoid density *i.e.*, 100 adults were tested at three radial distances (4, 8 and 12 m) in varieties CoLk 94184, CoLk 0238 and Co 0238. Rate of parasitism varied from 82.1% at closer distance (4 m) to 18.2% when the sentinel host pupa of top borer was set at 12 m from the releasing point.

Maintenance of natural population of insect-pests of sugarcane

Top borer

Natural population of insect pests and their parasitoids were observed in different varieties at Institute research farm. Incidence of second brood of top borer was the highest in CoLk 11203 (19.8%) followed by BO 91 (12.2%), Co 7717 (11.7%), Co 1148 (10.2%), CoS 767 with the least susceptible varieties were Khakai, CoJ 64, CoC 671, CoLk 94184, CoLk 13204 and CoS 8436. Maximum incidence of third brood was observed in CoLk 11203 (20.6%) followed by Co 0238 (16.2%), CoLk 8102 (15.6%) with the lowest incidence ranged from 5.1-12.5% in CoJ 64, Co 7717, CoC 671, Co 1148, CoLk 13204, CoS 8436, Khakai, CoLk 94184 and CoLk 11206. Minimum incidence of fourth brood was recorded in CoS 767, CoJ 64, CoS 8436, CoLk 11206, Co 0238 and BO 91 (ranged 9.9-17.8%). Susceptible variety was CoLk 8102 (26.3%) followed by CoC 671 and CoLk 11203. At harvest, most susceptible variety was CoLk 11203 followed by CoS 767 and CoLk 11206. The least susceptible varieties were CoJ 64, Co 7717, CoC 671, *Khakai*, Co 1148, CoLk 94184, CoLk 13204, CoS 8436, CoLk 8102, Co 0238 and BO 91, its incidence ranged from 1.0 to 8.6% (Fig. 3.6).

Stalk borer

Incidence of stalk borer in standing cane (August) varied from 5.5 to 13.7% in different varieties (Fig. 3.6). Susceptible varieties were CoLk 13204 and CoLk 8102 and, its incidence recorded up to 48% at the time of harvest. Five-six caterpillars/feeding tunnel encountered in a single cane. The least susceptible varieties were CoC 671, CoLk 11203, CoJ 64 and Co 7717.

Internode borer

Incidence of internode borer ranged from 2.4 to 14.4% in different varieties in the month of August. The highest incidence was observed in *Khakai* (22.5%) followed by Co 1148 (20.0%) with the least incidence in CoS 767, CoS 8436, CoLk 11203, BO 91 and CoC 671 (Fig. 3.6).

Mealy bug

Incidence of mealy bug, *Saccharicoccus sacchari* was observed in standing cane in the month of November. Maximum incidence was observed in CoC 671 (26.3%) followed by CoLk 13204 (23.7%) and Co 7717 (22.8%). Average incidence was 10.0-18.8% (Fig. 3.6).

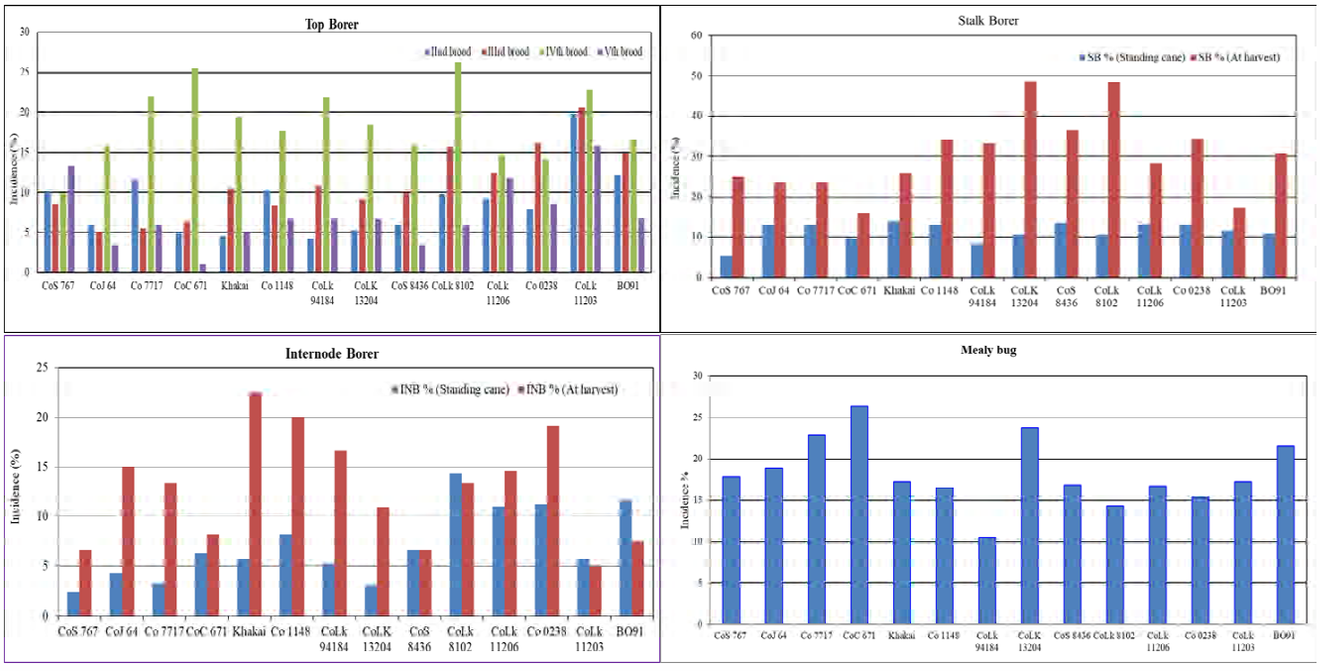


Fig. 3.6. Incidence of borers in different varieties at IISR research farm

Field parasitisation of different broods of top borer larvae

Field parasitisation of larvae of top borer (first to fourth broods) by three parasitoids *i.e.*, *Isotima javensis, Rhaconotus scirpophagae* and *Stenobracon niceviilae* was observed in two early varieties (CoLk 94184 and CoLk 11203) and two mid late varieties (CoLk 8102 and CoLk 13204) (Fig. 3.7). Extent of parasitisation was observed as 21.0%, 37.5%, 10.0% and 20.0% in CoLk 94184, CoLk 11203, CoLk 8102 and CoLk 13204, respectively in first brood of sugarcane top borer. First brood of top borer was parasitised by *I. Javensis* (28.1%) and *S. nicevillae* (9.4%). In second brood, maximum parasitisation was observed in CoLk 11203 (44.1%) followed by CoLk 8102 (39.9%), CoLk 13204 (34.2%) and 24.8% in CoLk 94184. Mortality of larvae of top borer by three parasitoids was the highest in third brood (43.3 -54.0%) and fourth brood (35.3-72.9%) in all the four varieties.

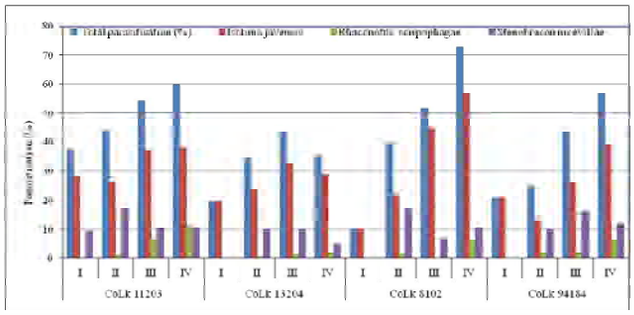


Fig. 3.7. Field parasitisation of different broods of top borer larvae

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

Six genotypes *viz*., Co 16029, Co 15025, CoLk 16201, CoPb 16181, CoLk 16202, CoLk 14201 and three standard checks (CoJ 64, Co 0238, Co 05009) in AVT (Early)-II Plant and in AVT (mid-late)-II plant, five genotypes *i.e.* Co 16030, CoLk 16203, CoS 16232, CoLk 16204, CoS 16233 including three standards *i.e.* Co 05011, CoPant 97222, CoS 767 were evaluated against top, stalk and internode borer.

Five genotypes *viz*., CoLk 16201, CoLk 16202, CoPb 16181, Co 15025, Co 16029 and three standard checks (CoJ 64, Co 0238, Co 05009) in AVT (Early)-Ratoon whereas in AVT (mid-late)-ratoon five genotypes *i.e.*, Co 16030, CoLk 16203, CoLk 16204, CoS 16232, CoS 16233 including three standards *i.e.*, Co 05011, CoPant 97222 and CoS 767 were evaluated against top, stalk and internode borer.

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

Co 0238 was monitored for borers, termites, mealy bug and mite pests. Top borer was major pest recorded. Incidence of 1st brood was 36.4%, 2nd brood was 25.4%, third brood was 26.2 and 5th brood was 18.0%. Stalk borer (15%) and internode borers (8.2%) were observed at cane maturity. Termites and mealy bugs incidence were low.

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

Trichogramma chilonis Ishii is a gregarious endo-parasitoid most widely produced and released against sugarcane borers. Biological attributes of sugarcane adapted strain of *T. chilonis* (collected from egg masses of top borer) was studied in F_1 to F_{10} generations on eggs of *Corcyra cephalonica* in the laboratory at 28 ± 2°C and 60 ± 5 per cent relative humidity. The fecundity rate was high in early generations compared to F_6-F_{10} generations. The female ratio was found more than 50% in all the generations. Wild strain of *T. chilonis* didn't readily accept the *Corcyra* eggs as laboratory host with only a few females parasitizing and laid more eggs in F_1 generation. The wild strain of *T. chilonis*, when taken to the laboratory, loose variability due to limited selection in breeding (crossing among siblings) gaining through an adaptation period with larger variations in their biological attributes.

Cotesia flavipes (Hymenoptera: Braconidae) as larval parasitoid of sugarcane borers. It was multiplied on stalk and internode borer larvae (4th instar) in the laboratory at 28 ± 20°C and 60 ± 5 per cent relative humidity. After parastisation, larvae were transferred on sugarcane stalk for further development. Coccons of *Cotesia* were collected three weeks after parasitisation. 20-26 adults emergence per cocoon with 1:1 (F:M) ratio.

Tetrastichus howardi (Hymenoptera: Eulophidae) as larval and pupal parasitoid of sugarcane is a potential candidate for biological control of sugarcane borer. *T. howardi* was maintained on the pupa of sugarcane top borer, *Scirpophaga excerptalis*. Newly emerged mated females of *T. howardi* were kept singly in glass vials (15 x 2.5 cm). The weight of each pupa was recorded on electronic balance. Each individual female parasitoid was provided with a pupa of *S. excerptalis, C. auricilius, C. partellus, S. inferens*, *A. mylitta* and *B. mori*, separately. Fine streaks of honey- water solutions (1:1 v/v) were provided as adult food and the glass vials were plugged with cotton wool. The individual females were allowed for 24 h for parasitization and then removed. The experiment was conducted at 26 ± 20°C and 65 ± 5% RH with five replications. The observations were taken (after emergence of parasitoid) on the development period, the number of progenies emerged per pupa and the female emergence. The sex of adult parasitoids was determined by assessing the morphological characteristics of their antennae and abdomen. The mean number of progenies was observed (60.80 to 408.6) on various host pupae. Progeny production/pupa was maximum on mulberry silkworm (408.60) and minimum on stalk borer (60.80). The number of progenies was comparatively less on maize stem borer, top borer and stalk borer (less weighed pupa) than large weighed pupa (pink borer, mulberry and *tasar* silk worm). Female biased sex ratio (>90%) was observed in tested pupae.

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

Per cent incidence of top borer (third-fifth brood) in treated plot and untreated plot recorded 1.3-9.3 and 18.7-34.7, respectively in CoLk 94184. However, incidence of stalk and internode borer ranged 41.3-48 % and 22.7-26.7%, respectively in control and 10-16% and 6.7-8.0% in treated plot.

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

Six isolates of entomopathogenic *Bacillus thuringiensis* (namely Btg1, Btg2, Btg3, Btg4, Btg5 and Btg6) which causes septicaemia in the larvae of *Galleria mellonella* were isolated from diseased and dead cadavers collected from the rearing unit. In the initial screening of these isolates for their biocidal activity, the third instar larvae were allowed to feed on the diet inoculated with 10^8 spores per gram of feed. This screening study showed that isolates Btg3 and Btg6 causes 100% mortality in fully grown larvae after 96 hrs of inoculation. The eighteen *B. thuriengensis* isolates and fifteen isolates of *Brevibacillus* sp. isolated from sugarcane rhizospheric soil, were screened for biocidal activity against the grubs of *Holotrichia* sp. In this study, 2nd and 3rd instar grubs were allowed to feed on 5 mm^2 size potato cube inoculated with spore (10^8 per ml) for 48 hrs, after those grubs were transferred in soil and sand mix in 200 ml beaker which is incubated at 28°C for 45 days during this incubation time feed were replaced ever week. It was found that except Br3 isolate of *Brevibacillus* sp., none of the isolates produces disease symptoms or mortality in 2nd and 3rd instar white grubs.

Utilization of entomopathogenic nematodes against white grubs infesting sugarcane

Morphological and molecular characterization of entomopathogenic bacteria (EPBs) associated with EPNs was done this year. G. *mellonella* larva killed by EPN were dissected aseptically under a laminar airflow cabinet and haemolymph was streaked on MacConkey agar media. The streaked plates were incubated in a BOD incubator at 28°C for 24 to 48 hours for bacterial growth. The round, pinkish colonies of bacteria were observed on the plate, however, a single bacterial colony was picked up and freshly inoculated to media. The isolated bacterium was found to be gram-negative (Gram staining test) and sucrose utilising (phenol red indicator test). The partial sequence (1049 bp) of the 16S rRNA

bacterial gene was generated and deposited into the NCBI Gene Bank database (Accession No. MZ413351) and identified as *Ochrobactrum* (Brucella) *anthropi*. Various studies suggested that the *O. anthropi* bacterium is closely associated with *Photorhabdus* spp. and have a prominent role in insect pathogenesis.

Bio-efficacy assay of *Heterorhabditis indica* against different instars of white grubs (*Holotrichia serrata* and *Phyllognathus dionysius*) was conducted

Eggs, different instars and the adult beetles were hand-picked from the host trees (*neem*, *ber*, manila tamarind *etc.*) at a dusk time nearby to Pravaranagar area. The specimen samples of the beetles were sent for identification at the Division of Germplasm Collection and Characterization, ICAR-NBAII, Bengaluru. Based on the morphological features, the beetles were segregated and reared separately in a rearing cage containing soil: sand mixture (3:1). Freshly laid eggs were white, oval, small and change to brownish before hatching (hatching period:12 to15 days). All identified native EPN strains were also maintained and mass-produced in the laboratory by infecting *Galleria* larvae and revived periodically.

The bioassay experiment was carried out against the first, second and third instar grubs of *Holotrichia serrata* with *H. indica*, separately. Different dosage of infective juveniles (IJs) was prepared and the grub mortality of each grub instar was monitored after HAI (hours after IJs inoculation). 80%, mortality was recorded in first instar grubs at 100 IJs dose, 84% mortality in second instar grubs was recorded at 1,000 IJs dose and 93% mortality in third instar grubs at 10,000 IJs dose was recorded. Similarly, the bioassay experiment was executed against the first and second grub instars of *Phyllognathus dionysius*. At 100 IJs dose, 81% mortality was observed in first instar grubs and at 500 IJs dose 78% mortality was recorded in second instar grubs (Fig. 3.8).

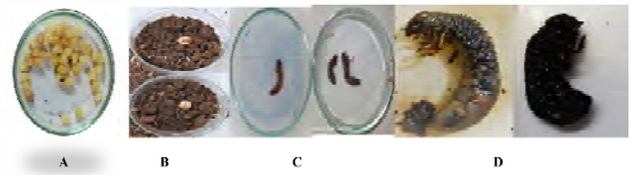


Fig. 3.8. Eggs of white grub (A), First instar grubs of white grub (B), Second and third (C) instar grubs killed by EPN (D)

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

Set of experiments were laid under two initial SOC levels (<0.5 and >0.9) to evaluate impact of different nutrient sources and agrochemicals on beneficial soil fauna and flora and also major pests of sugarcane. Experiments were designed in RBD with three replications and sixteen treatments (NPK, FYM at recommended doses in combination with insecticides and herbicides). Treatments were as follows, T1- NPK as per recommended doses (150:60:60), T2 – NPK + FYM in recommended doses; T3- FYM (@ 10 t/ha) in recommended doses; T4 - control (zero fertilizer); T5- NPK+ Chlorpyriphos 20 EC @ 6.25 l/ha) ; T6- NPK+ Chlorantraniliprole 0.4 GR @ 18.75 kg/ha) ; T7- NPK+ Weedicide (atrazine 50 WP @ 2 kg ai/ha followed by 2-4-D 95 WP @ 1 kg ai/ha); T8- NPK+FYM+chlorpyriphos; T9-NPK+FYM+Chlorantraniliprole; T10-NPK+FYM+ weedicide, T11-FYM+Chlorpyriphos, T12-FYM+ chlorantraniliprole, T13-FYM+weedicide, T14- Control+ Chlorpyriphos, T15- Control+ Chlorantraniliprole, T16- Control+weedicide.

Observation on microarthropods, soil microflora and nematodes abundance and diversity were recorded at three stages of cane growth *viz.*, sprouting, tillering, grand growth phase and at maturity. While borer incidence was recorded at cane maturity *i.e.*, around October/ November month.

Results indicated that diversity and abundance of microarthropods were inclined to crop growth stages and initial SOC level of soil. Abundance and diversity increased from tillering to maturity. Combination of NPK+FYM as nutrient source significantly supported faunal build-up and diversity. Higher initial SOC supported higher diversity and abundance (Fig. 3.9).

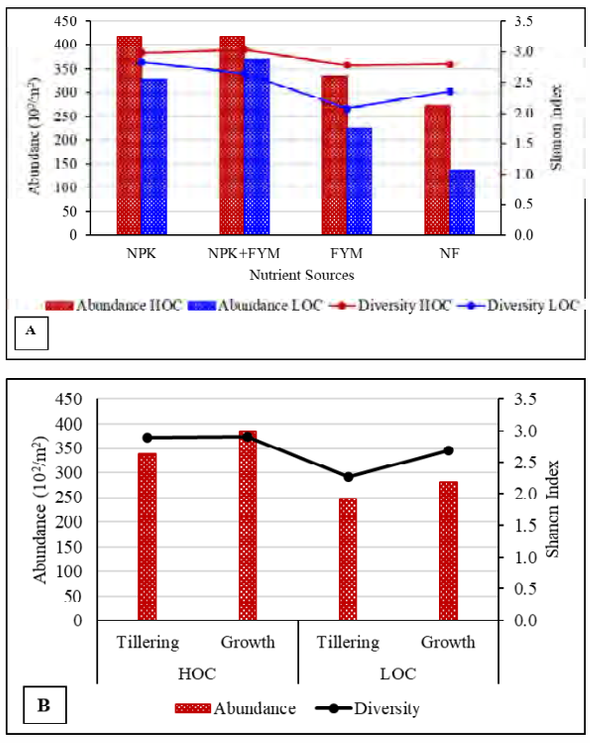


Fig. 3.9. Abundance and diversity of soil microarthropods under different sources of nutrition (A) and at different crop stages (B)

Incidence of top borer, internode borer and stalk borer were significantly higher in NPK, followed by NPK +FYM. Pest incidence in FYM was at par with control. Similar trend observed in combination of nutrient sources and pesticides treatments. However, damages due to different borers was higher in FYM + weedicide treated plots. A significantly higher yield was recorded in all the treatments over control.

Bacteria was observed to be the dominant microbial community in all treatments irrespective of the initial carbon status of the soils. In general, the population varied between 11.0×10^7 and 32.7×10^7 cfu/g for bacteria, 2.3×10^5 and 10.7×10^5 cfu/g soil for actinomycetes and 0.0×10^2 and 1.7×10^2 cfu/g soil for *Trichoderma* spp. across the treatments. In case of fungal populations, there was no impact of the various treatments on total fungal population in soils with high organic content; however, soils with low organic carbon the various pesticide treatments stimulated the total culturable fungal population. In low organic carbon soils, under zero fertilizer application, fungal population recorded was in range of 19.7 to 24.7×10^4 cfu/g soil across the three pesticide treatments as compared to 3.3×10^4 cfu/g soil in control. Similarly, fungal population observed in soils with pesticide application along with NPK (16.3 to 20.3 $\times10^4$ cfu/g soil), FYM (18.3 to 26.7×10^4 cfu/g soil) and NPK + FYM (11.3 to 25.7×10^4 cfu/g soil) was considerably higher than their respective controls (8.7, 11.7 and 6.0×10^4 cfu/g soil, respectively). These findings indicated that application of these pesticides had a more significant impact on soil microbial communities especially fungi, when applied under soils with low initial organic carbon.

Nematodes were observed in different trophic groups as predatory, bacterivores, herbivores and omnivores nematodes. The herbivores group was observed as the most dominant group of nematodes in all the soil samples. Among the herbivores nematode genera *viz*., *Criconematids*, *Hemicriconematids* and *Longidorus* were predominant. Bacterivore's nematodes *viz*., *Cephalobus* spp. and *Rhabditids* spp. were occurred most. Initial carbon status of the soils influenced abundance of bacterivore nematodes. In higher SOC, soil population was more (37.26%) compared to low SOC soils where population of bacterivore's nematodes were low (24.34%).

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

During the year, seventy-six germplasm/ genotypes were screened against red rot (CF 08 and CF 13) and smut. Natural incidence of wilt and Yellow Leaf Disease (YLD) were also recorded (Table 3.2).

Table 3.2. Reaction of genotypes against red rot pathotypes (CF 08 and CF 13), wilt, smut and YLD

Reaction	Genotypes
Red rot pathotypes (CF 08 and CF 13)	
R	A-21, A-32, LG 18691 & LG 18136
MR	A-3, A-14, A-17, A-19, A-20, A-22, A-25, A-27, A-29, A-31, A-33, A-34, A-36, LG 18016, LG 18074, LG 18106, LG 18146, LG 18158, LG 18235, LG 18246, LG 18310, LG 17154, LG 18762, LG 18309, LG 18032, LG 18082, LG 18907, LG 18945
MS	A-12, A-13, A-18, LG 18150, LG 18478
S	A-1, A-8, LG 17105, LG 18178, LG 18369
HS	A-4, A-16, A-24, LG 18384 & LG 18808, LG 18991
Red rot pathotypes (CF 13)	
R	LG 18782
MR	A-2, A-5, A-6, A-9, A-10, A-26, A-28, A-30, A-37, LG 17129
MS	A-35, LG 18095, LG 18339
S	A-11, A-15, LG 17179, LG 17130, LG18078
HS	A-7, A-23, LG 18071, LG 18085, LG 18218, LG 18299
Red rot pathotypes (CF 08)	
R	-
MR	A-7, A-15, LG 17179, LG 18095, LG 18339, LG 18782 LG 18299, LG 18218, LG18078
MS	A-9, A-10 A-11, A-23, A-28, LG 18071, LG 18085
S	A-5, A-6, A-37, LG 17129
HS	A-2, A-26, A-30, A-35, LG 17130
Smut	
R	A-5, A-9, A-11, A-14, A-15, A-17, A-18, A-21, A-22, A-23, A-24, A-29, A-30, A-32, A-35, A-37, LG 18310, LG 18071, LG 18074, LG 18691, LG 18991, LG 18246, LG 18106, LG 18095, LG 18146, LG 18078, LG 18299, LG 18235, LG 18384, LG 17105, LG 18158, LG 18907, LG 18218, LG 17179, LG 17154, LG 18085, LG 18478, LG 17129, LG 18808, LG 17130, LG 18178, LG 18082, LG 18369 and LG 18136
MR	A-1, A-4, A-12, A-13, A-20, A-33, A-36, LG 18016 and LG 18339
MS	A-2, A-6, A-8, A-19, A-25, A-31, A-34, LG 18032 and LG 18782
S	A-3, A-10, A-16, A-26, A-28, LG 18762, LG 18309 and LG 18150
HS	A-7, A-27 and LG 18945
Wilt	
R	A-1, A-2, A-3, A-4, A-8, A-9, A-10, A-11, A-13, A-17, A-19, A-21, A-22, A-25, A-29, A-31, A-32, A-33, A-34, A-36, A-37, LG 18945, LG 18310, LG 18071, LG 18074, LG 18106, LG 18095, LG 18146, LG 18016, LG 18078, LG 18917, LG 18299, LG 18757, LG 18384, LG 17105, LG 18907, LG 18218, LG 17179, LG 17154, LG 18085, LG 18478, LG 17129, LG 18808, LG 18032, LG 17130, LG 18178, LG 18082, LG 18339, LG 18782, LG 18136, LG 18347 and LG 18150
S	A-5, A-6, A-7, A-12, A-14, A-15, A-16, A-18, A-20, A-23, A-24, A-26, A-27, A-28, A-30, A-35, LG 18691, LG 18991, LG 18246, LG 18235, LG 18158, LG 18762, LG 18309 and LG 18369
YLD	
R	A-2, A-3, A-4, A-5, A-6, A-7, A-8, A-10, A-11, A-13, A-14, A-15, A-16, A-17, A-18, A-19, A-21, A-22, A-23, A-24, A-25, A-26, A-27, A-28, A-29, A-30, A-31, A-32, A-33, A-34, A-35, A-36, A-37, LG 18945, LG 18310, LG 18071, LG 18074, LG 18991, LG 18106, LG 18095, LG 18146, LG 18078, LG 18917, LG 18299, LG 18235, LG 18757, LG 18158, LG 18907, LG 18218, LG 17179, LG 17154, LG 18085, LG 18762, LG 17129, LG 18309, LG 18808, LG 18032, LG 17130, LG 18178, LG 18082, LG 18369, LG 18782, LG 18136, LG 18347 and LG 18150
S	A-1, A-9, A-12, A-20, LG 18691, LG 18246, LG 18016, LG 18384, LG 17105, LG 18478 and LG 18339

R = Resistant; MR= Moderately resistant; S = Susceptible; MR = Moderately susceptible

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

Yellow Leaf Disease (YLD) infected cane of sugarcane cv. Co 1148 was treated with five different heat treatments in MHAT machine. The treatments were T1 = 2h first day +2h second day +2h third day of MHAT at 50°C; T2 = 2h first day +1h second day +1h third day of MHAT at 50°C; T3 = 2h first day +2h second day +1h third day of MHAT at 500C; T4 = 1h first day +1h second day +1h third day and T5 = Normal MHAT (54°C for 2 h 30 m) along with two controls (T6 Healthy seed cane; T7 Diseased seed cane). Sum total of six observations has been recorded each after 50 days intervals on visual basis.

Results revealed that none of the treatments along with control was found infected with the YLD up to the crop age of 150 days. Appearance of YLD symptoms was noticed first at 200 days old crop with 7 (seven) plants of T4 and 12 (twelve) plants in T7. At the age of 250 days old crop, T2, T3, T4, T6 and T7 recorded YLD infection in 12, 11, 17, 11 and 22 plants, respectively. At the age of 300 days old crop, all the treatments were found infected with YLD infection in 3, 20, 15, 21, 5, 16 and 33 plants, respectively. At the crop age of 350 days, higher increase in the number of Yellow Leaf Disease infected cane were observed and counted as 7, 26, 23, 70, 11, 22 and 62 plants, respectively. Out of all seven treatments tested, none of the treatment was found effective for crop plant to overcome the infection of YLD virus from the seed cane. It has noticed that T1 (Serial thermotherapy of two hours through MHAT at 50°C for three consecutive days) and standard MHAT both were found effective for crop plant to overcome the infection of YLD virus up to the crop age of 200 days and lowered the infection up to the maturity of seed cane.

T1 recorded 48.00% germination, 0.85 kg cane weight, 2.01 m cane length, 2.22 cm cane girth, 115 thousand millable cane with 81.10 tonnes yield. T5 recorded 30.00% germination, 0.82 kg cane weight, 1.98 m cane length, 2.15 cm cane girth, 97 thousand millable cane with 72.80 tonnes yield.

Management of pokkah boeng disease of sugarcane

The isolated and identified potential pathogenic *Fusarium* spp. (*Fusarium proliferatum* and *Fusarium moniliforme*) were tested for pathogenicity test. Three inoculation methods (sett treatment, soil application, and foliar application) were adopted for disease development. The foliar application was done at 45 days after planting. The 10^7 conidia per ml were maintained and used. Sterilized water sprayed over seedlings was used as a control. Regular observations were recorded on the disease development. Disease incidence and disease severity was calculated. Maximum disease development was recorded on foliar-applied pathogenic inoculum followed by soil application. In another study, potential microbial cultures were evaluated to check pokkah boeng infection. *Trichoderma* spp. and bacterial cultures were applied as sett treatment and foliar spray at 45 days of planting. The pathogenic inoculum was sprayed over antagonistic cultures treated tillers at 45 days of planting. Foliar spray of chemical fungicides (carbendazim and mancozeb) -treated plants were considered as standard control. Weekly observations were recorded on disease incidence and disease severity. *Trichoderma* treated setts and its foliar application were observed for low disease development which was at par with standard chemical control.

Isolation, identification and pathogenicity of wilt pathogen in sugarcane

Survey was conducted to collect wilt diseased sugarcane samples from different varieties from Uttar Pradesh (ICAR-IISR, Lucknow campus; Faizabad, Lakhimpur Kheri and Hardoi), Punjab (Ludhiana) and Bihar (Motipur). Disease incidence ranged from 2-60%. Out of 35 cultures, 16 (45.7%) were identified as *Fusarium* sp. Out of these 16 *Fusarium* cultures, eight (50.0%) cultures were cottony and fluffy pinkish-white, 4 (26.6%) cultures were cottony and fluffy white, while 4 (26.6%) cultures were cottony dull white. All the 16 cultures showed light reddish yellow colour at the bottom of the Petri plates. Growth rate of the fungus ranged from 0.5-0.9 cm/day at 27°C. Microconidia were oval with a single septum, while macroconidia were sickle-shaped with 2-3 septa (Fig. 3.10).

Fig. 3.10. *Fusarium* wilt of sugarcane

Evaluation of selected *Trichoderma* isolates for management of smut of sugarcane

A field trial was carried out during 2021-22 crop season to evaluate five *Trichoderma* isolates (three rhizospheric and two endophytes) for their potential to control smut of sugarcane. The trial was laid out in a randomized block design with var CoLk 11203 with 7 treatments and three replications: T1: Treatment with isolate STr-83; T2: Treatment with isolate STr-85; T3: Treatment with isolate STr-108; T4: Treatment with isolate SER-10; T5: Treatment with isolate SER-42; T6: Control (smut inoculated setts); and T7: Healthy Check. The *Trichoderma* isolates were applied as sett treatment and soil application through FYM at time of planting.

Three bud setts of var CoLk 11203 were dipped in *Trichoderma* suspension (metabolites + spores) for one hour and then shade dried for 1-2 h. The shade-dried setts were then soaked in smut spore suspension (106 spores/ml) for 30 min and planted. Data on germination, smut incidence and yield were recorded. The results revealed that the germination ranged between 25.6% (control) and 34.2% (healthy check) in the different treatments. Incidence of smut ranged from 11.5% (STr-83) to 34.7% (control). Among the five *Trichoderma* isolates, application of two isolates (STr-83 & SER-42) showed considerable reduction in smut incidence over control (> 40% reduction). In terms of yield also, the highest yield was also recorded in healthy check (63 t/ha) followed by treatment with STr-83 (62.0 t/ha) and SER-42 (51.9 t/ha) while lowest yield was observed in control. These findings indicate that *Trichoderma* spp. have the potential to manage smut of sugarcane and need to be explored further.

Identification of pathotypes in red rot pathogen

During 2021-22, 10 new isolates *i.e.* six isolates from Co 0238 (IR-195, IR-196, IR-198, IR-202, IR-203 and IR-204); two isolates from Duplicate CoLk 94184 or unknown variety (IR-197 and IR-201) and two isolates from CoS 8436 (IR-199 and IR-200) were evaluated for their pathogenic virulence spectrum along with CF 07, CF 08, CF 09 and CF 13 on 20 designated differentials *viz.*, BO 91, Co 419, Co 975, Co 997, Co 1148, CoS 8436, Co 7717, Co 62399, CoC 671, CoJ 64, CoS 767, Co 7805, Co 86002, Co 86032, CoSe 95422, CoV 92102, Co 0238, *Khakai* (*S. sinense*), SES 594 (*S. spontaneum*) and *Baragua* (*S. officinarum*) by plug method of inoculation. The virulence pattern of all the studied isolates were more or less matched with the existing pathotypes of this zone CF 07, CF 08, CF 09 and CF 13. Hence, there is no emergence of any new virulent pathotype in this zone.

Evaluation of zonal varieties against red rot, smut and wilt

Thirty-eight genotypes were planted and screening for North West Zone against red rot, smut and natural infection of wilt and yellow leaf disease along with susceptible checks at IISR, Lucknow (Table 3.3) and 24 genotypes were screened for North Central Zone, against red rot, smut, wilt and YLD at IISR RC, Motipur (Table 3.4).

Assessment of elite and ISH genotypes for resistance to red rot

Twenty four ISH genotypes namely ISH 501, ISH 548, ISH 536, ISH 524, ISH 542, ISH 526, ISH 594, ISH 585, ISH 519, IGH 823, ISH 558, ISH 545, IGH 834, IGH 833, ISH 590, ISH 562, ISH 584, ISH 587, ISH 502, ISH 528, IGH 829, ISH 554, ISH 567 and ISH 516 along with two susceptible checks CoJ 64 (for CF 08) and Co 0238 (for CF 13) were planted at ICAR-Indian Institute of Sugarcane Research, Lucknow for the evaluated against red rot disease of sugarcane pathotypes CF 08 and CF 13.

Table 3.3. Reaction of sugarcane genotypes against red rot, smut and wilt at IISR, Lucknow

Sl. No.	Genotype	Red Rot				Smut	Wilt	YLD
		Plug method		Nodal method				
		CF 08	CF 13	CF 08	CF 13			
Initial Varietal Trial (Early)								
1.	CoS 17232	MR	MR	R	R	S	-	-
2.	CoPb 18181	MR	MR	R	R	HS	-	-
3.	CoPb 18182	MR	MR	R	R	R	W	-
4.	CoLk 18201	MR	MR	R	R	MR	-	-
5.	CoLk 18202	MR	MR	R	R	MS	-	-
6.	CoPb 18211	MR	MS	R	S	R	W	-
7.	CoPb 18212	MS	HS	S	S	S	W	Y
8.	CoPant 18221	MS	MR	S	R	MS	W	Y
Advanced Varietal Trial (Early) – II Plant								
1.	CoLk 14201	MR	MR	R	R	R	-	-
2.	Co 15025	MR	MR	R	R	R	W	-
3.	Co 16029	MR	MR	R	R	MS		-
4.	CoLk 16201	R	R	R	R	MS	-	Y
5.	CoLk 16202	MR	MR	R	R	R	-	-
6.	CoPb 16181	MR	MR	R	R	R	-	-
Initial Varietal Trial (Mid-late)								
1.	Co 18021	Seed was not available for testing						
2.	Co 18022	MS	MR	S	R	S	W	Y
3.	CoLk 18203	MR	MR	R	R	R	-	-
4.	CoLk 18204	R	R	R	R	MR	-	-
5.	CoPb 18213	Seed was not available for testing						
6.	CoPb 18214	MR	MS	R	S	R	W	-
7.	CoPant 18222	MS	MR	S	R	R	W	Y
8.	CoS 18231	MS	MS	S	S	R	-	Y
9.	CoS 18232	MR	MR	R	R	R	-	-
10.	CoS 18233	MR	MR	R	R	MS	-	-
11.	CoS 18234	MR	MR	R	R	MR	-	-
Advanced Varietal Trial (I-Plant Mid-late)								
1.	Co 17018	MR	MR	R	R	S	W	-
2.	CoLk 17204	MR	MR	R	R	R	-	-
3.	CoPb 17215	MR	MR	R	R	R	-	Y
4.	CoPant 17223	MR	MR	R	R	R	W	Y
5.	CoS 17234	MR	MR	R	R	R	W	-
6	CoS 17236	MR	MR	R	R	-	-	-
7	CoH 17261	MR	MR	R	R	R	-	-
8	CoH 17262	S	S	S	S	R	-	-
Advanced Varietal Trial (Mid-late) – II Plant								
1.	Co 16030	MS	MS	R	R	R	W	Y
2.	CoLk 16203	MR	MR	R	R	R	-	-
3.	CoLk 16204	R	R	R	R	R	-	Y
4.	CoS 16232	MR	MR	R	R	R	-	-
5.	CoS 16233	MR	MR	R	R	R	W	Y
Check	CoJ 64*			-	-		-	-
Check	Co 0238*			-	-		-	-
Check	Co 1158**	-	-	-	-		-	-
Check	CoLk 7701**	-	-	-	-		-	-

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

Table 3.4. Reaction of sugarcane genotypes against red rot, smut, wilt and YLD at IISR Regional Centre, Motipur

Sl. No.	Genotype	Red Rot				Smut	Wilt	YLD
		Plug method		Nodal method				
		Cf 08	Cf 13	Cf 08	Cf 13			
Initial Varietal Trial (Early)								
1.	CoP 18436	S	MS	S	R	R	-	-
2.	CoP 18437	MR	MR	R	R	R	W	Y
3.	CoP 18438	R	R	R	R	MS	-	-
4.	CoSe 18451	MR	MR	R	R	R	-	-
5.	CoSe 18452	MR	MR	R	R	R	-	Y
Advance Varietal Trial (I-Plant, Early)								
1.	CoSe 16454	MR	MR	R	R	-	-	-
2.	CoP 17436	MR	MR	R	R	-	-	-
3.	CoP 17437	MR	MR	R	R	-	-	-
4.	CoP 17438	MR	MR	R	R	R	-	-
5.	CoP 17440	MR	MR	R	R	R	-	Y
6.	CoP 17441	MR	MR	R	R	MS	W	-
7.	CoSe 17451	MR	MR	R	R	MR	W	Y
Advance Varietal Trial (II-Plant, Early)								
1.	CoP 16437	MR	MR	R	R	-	-	-
2.	CoP 16438	MR	MR	R	R	MR	W	-
3.	CoLk 16466	MR	MR	R	R	MR	-	-
4.	CoLk 16468	MR	MR	R	R	MR	-	-
5.	CoSe 16451	MS	MS	S	S	R	-	-
Advance Varietal Trial (Mid-late) - I Plant								
1.	CoSe 16455	MS	MS	S	S	R	-	Y
2.	CoP 17446	MR	MR	R	R	-	W	-
3.	CoSe 17452	MS	MS	R	R	-	W	-
Advance Varietal Trial (Mid-late) – II Plant								
1.	CoP 16439	MR	MR	R	R	MS	-	Y
2.	CoLk 16470	MR	MR	R	R	R	-	Y
3.	CoSe 16452	MR	MR	R	R	MR	-	-
4.	CoBln 16502	MR	MR	R	R	-	W	-
Check	CoJ 64*	HS	MR	-	-	-	-	-
Check	Co 0238*	MR	HS	-	-	-	-	-
Check	Co 1158**	-	-	-	-	HS	-	-
Check	CoLk 7701**	-	-	-	-	HS	-	-

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

Fourteen genotypes *viz*., ISH 548, ISH 524, ISH 526, ISH 519, ISH 585, ISH 558, IGH 833, ISH 590, ISH 584, ISH 502, ISH 528, IGH 829, ISH 554 and ISH 567 were rated as moderately resistant (MR) to both the pathotypes (CF 08 and CF 13) by plug method of inoculation and resistant (R) by nodal method of inoculation.

Three ISH genotypes *viz*., ISH 501, ISH 536 and ISH 516 were rated as moderately resistant (MR) against pathotype CF 08 and susceptible (S) against pathotype CF 13 by plug method whereas, resistant (R) against pathotype CF 08 and susceptible (S) against pathotype CF 13 by nodal method of inoculation.

Four ISH genotypes *viz*., ISH 542, ISH 823, ISH 834 and 562 were rated as moderately susceptible (MS) against pathotype CF 08 and moderately resistant (MR) against pathotype CF 13 by plug method whereas susceptible (S) against pathotype CF 08 and resistant (R) against pathotype CF 13 by nodal method of inoculation.

Genotype ISH 594 was rated as susceptible (S) against pathotype CF 08 and highly susceptible (HS) against pathotype CF 13 by plug method whereas susceptible (S) against both the pathotypes (CF 08 and CF 13) by nodal method of inoculation.

Genotype ISH 545 was rated as moderately resistant (MR) against pathotype CF 08 and highly susceptible (HS) against pathotype CF 13 by plug method whereas resistant (R) against pathotype CF 08 and susceptible (S) against pathotype CF 13 by nodal method of inoculation.

Genotype ISH 587 was rated as susceptible (S) against pathotype CF 08 and moderately susceptible (MS) against pathotype CF 13 by plug method whereas susceptible (S) against both the pathotypes (CF 08 and CF 13) by nodal method of inoculation.

Artificial intelligence-based detection of disease and insect pest in sugarcane

The 3,853 leaf and cane images of healthy and infested symptoms of different insect, pest and diseases were categorised into 23 different classes. Of 23 classes, 10 belongs to different kinds of insect damage, 11 to various diseases, one to pest (Porcupine) and remaining one to healthy symptoms. Among insect damage, 461 images belong to top borer, 315 to internode borer, 280 to stalk borer, 195 to pink borer, 100 to root borer, 134 to termite, 10 to web-mite, 17 to white fly, 160 to fall armyworm and 112 to mealy bug. Amidst 1537 diseased images, 143 images depict symptoms of red rot, 372 to wilt, 164 to smut, 450 to pokkah boeng, 31 to red leaf spot, 18 to red stripe, 40 to ring spot, 102 to YLD, 94 to SCBV, 112 to ScMV and 11 to GSD. The 125 images belong to porcupine damage. The 407 images of healthy leaves and canes of sugarcanes were also captured for comparison with infested leaves and canes.

Characterization of yellow leaf disease pathogen(s) of sugarcane in sub-tropical India

The YLD susceptible germplasms *viz*., Co 1148, CoLk 94184, CoLk 14201 and Co 979 were planted during the spring season 2021 at ICAR-IISR, Lucknow and CoLk 94184, CoSe 16455, CoSe 15454, CoSe 17502 and CoLk 14209 at ICAR-IISR Regional Station, Motipur have been planted for maintenance of YLD inoculum. The germplasms Co 1148, CoLk 94184, CoLk 14201 and Co 979 showed YLD incidence ranging up to 50%. The collected samples will be used for further studies.

CHAPTER 4

Research in Plant Physiology and Biochemistry

Physiological and molecular bases of multiple abiotic stress tolerance in sugarcane

A pot culture experiment was conducted to identify physio-molecular traits associated with multiple abiotic stress tolerance in sugarcane. The seedlings of sugarcane variety CoS 767 were raised from single bud setts in plastic trays. Forty days old seedlings were then transplanted in earthen pots (10"diameter). After forty days of transplanting, stress treatments; drought, salinity and waterlogging were imposed for a period of 30 days. Growth, physiological, nutritional and molecular analysis were performed at the end of stress treatment. Among different stresses, drought caused maximum reduction in different growth parameters like, plant height, single cane weight, internode length, internode number, cane girth, fresh leaf weight, root weight and root volume. The physiological parameters, photosynthetic rate, stomatal conductance and chlorophyll stability index were also reduced the highest under drought condition. Compared to control, the catalase and peroxidase activity were increased under stress treatments; the highest increase in both enzymes were found in waterlogging treatment. The leaf electrolyte leakage and proline content were also increased under different stresses whereas, the highest values for both parameters were observed under drought treatment. Abiotic stresses induced a decline in leaf N, P, K, S, Ca, Zn and Cu concentration. Whereas, leaf Fe, Al and Mn concentrations were increased under waterlogging treatment. The leaf Na was found to be increased under salinity treatment. Transcriptomic analysis was conducted using total RNA as starting material from sugarcane leaf samples of CoS 767 at the end of stress. Database summary revealed that 66,595 transcripts were annotated by Refseq database, 21,216 transcripts were annotated by Uniprot and 32,805 transcripts were annotated by PFAM database. Results depicted a total number of 94,037, 94,226, 93,530 and 94,005 transcripts under control, drought, salinity and waterlogging treatments, respectively. Differential expression analysis revealed 177, 690 and 500 significantly up-regulated transcripts under drought salinity and waterlogging conditions. Whereas, 1961, 2074 and 2008 genes were found significantly down-regulated under drought salinity and waterlogging treatments, respectively. Differential expression of genes associated with carbon and energy function, nitrogen metabolism, hormone/ signaling genes, antioxidant enzymes, various transcription factors and different transmembrane transporters of potassium, copper, sulphur and phosphorus were found to be modulated due to different stress treatments. Genes like AAA-ATPase ASD, mitochondrial gene, protein zinc induced facilitator-like 1- isoform X2 gene, aldehyde dehydrogenase family 2 member B7 gene, Aldehyde dehydrogenase family 3 member F1 gene, Metal tolerance protein 1- like isoform X2 gene, metal tolerance protein A2 gene and metallothionein-like protein 2C gene were up-regulated commonly under drought, waterlogging and salinity treatment in tolerant variety CoS 767. Whereas, cytochrome P450 gene, potassium channel AKT1 isoform X1 and X2 gene, potassium transporter 1 and 7 gene, two pore potassium channel a isoform X1 and X2 gene, alcohol dehydrogenase 1 gene, peroxidase 51 gene, glutathione S-transferase gene, peroxisomal membrane protein 13 gene, myb-related protein 308-like gene, ABC transporter C and G family member genes, auxin response factor 4 and 8 gene, ACC oxidase, 1-aminocyclopropane-1-carboxylate oxidase 1 gene, Gibberellin receptor GID1-like gene, ethylene responsive transcription factors like ERF027, ERF109 and calcium-dependent protein kinase CDPKs 1, 4, 9 10, 20 etc genes were down-regulated commonly under drought, waterlogging and salinity treatments.

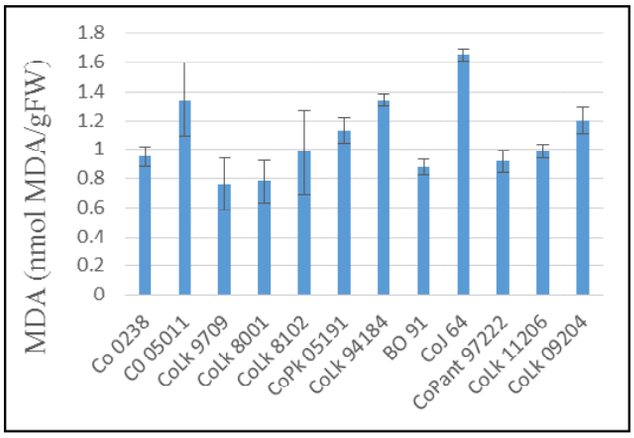
Fig. 4.1. Response of sugarcane to different abiotic stress

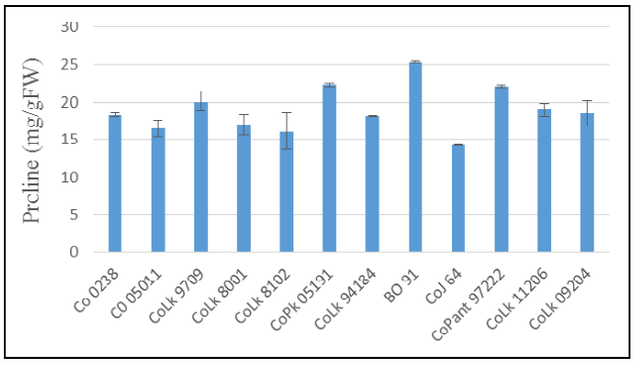
Understanding mechanisms of sugar accumulation and WUE in sugarcane through physio-biochemical studies

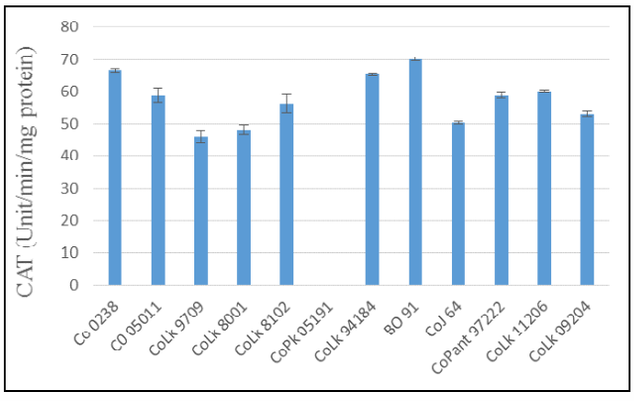
Twelve varieties of spring planted sugarcane *viz*., CoLk 11206, CoLk 09204, Co 0238, Co 05011, CoLk 9709, CoLk 8001, CoLk 8102, CoPk 05191, CoLk 94184, BO 91, CoJ 64, CoPant 97222 were evaluated for various physio-biochemical traits *viz*. lipid peroxidation measured in terms of malondialdehyde (MDA) content, proline,

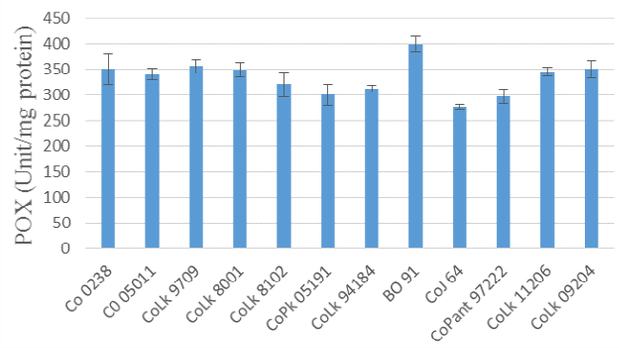
catalase (CAT) and peroxidase (POX) enzyme activity and chlorophyll pigments during grand growth phase.

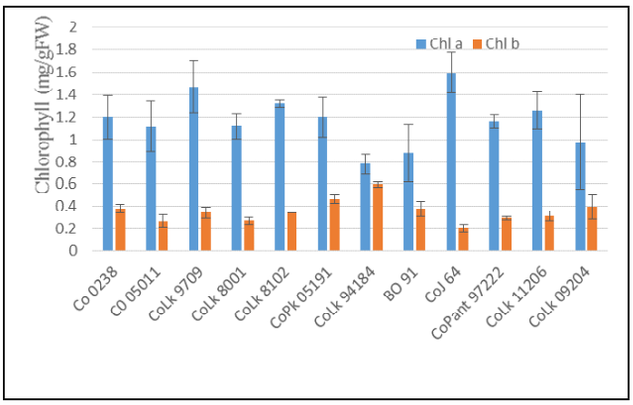
Variation was observed for all the traits at grand growth phase and variety BO 91 found to be superior for all these traits. Maximum lipid peroxidation was observed in var. CoJ 64 followed by Co 05011 and CoLk 94184. Performance of BO 91 was at par with CoLk 9709 and CoLk 8001. BO 91 also recorded maximum proline content followed by Co 05011 and CoPk 05191. Further, estimation of antioxidative enzymes catalase and peroxidise revealed better antioxidative capacity for both enzymes in var. BO 91 followed by CoLk 94184. All these parameters when combined with photosynthetic performances forms a better screening strategy for water use efficiency traits.







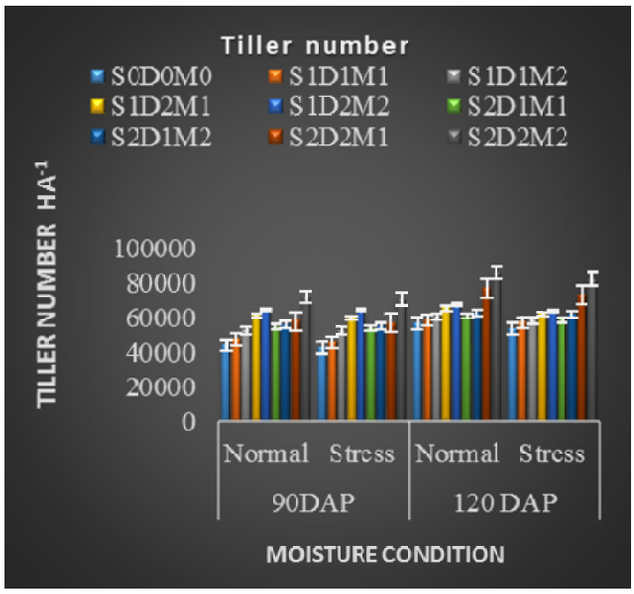


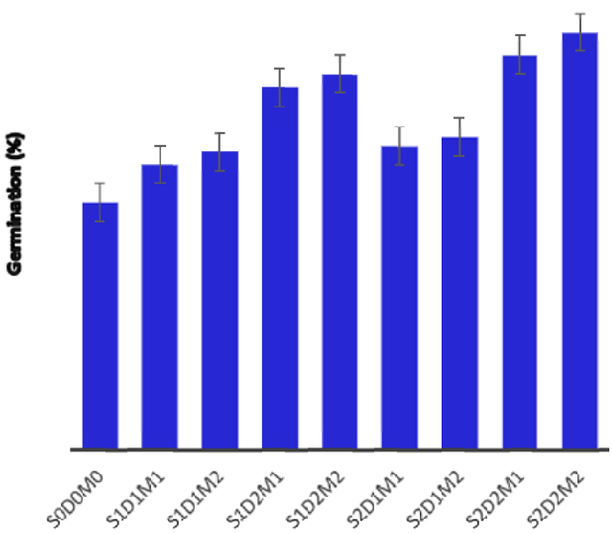


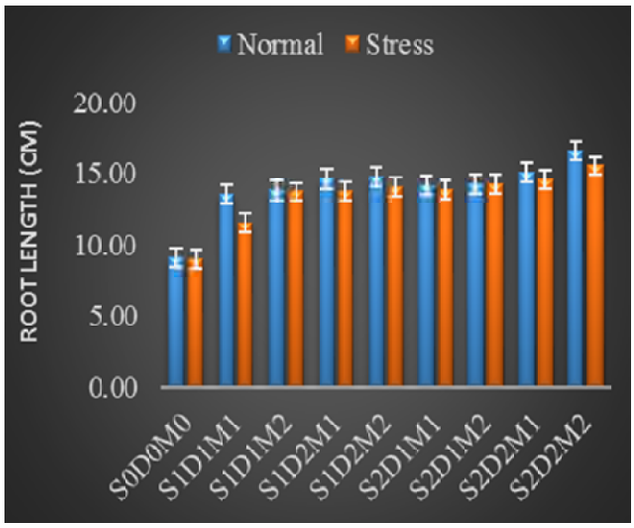
Evaluation of silica application in relation to moisture stress and productivity in sugarcane

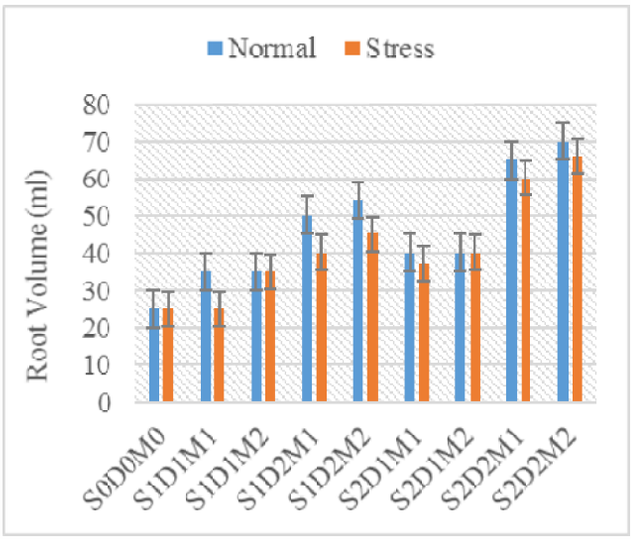
A field experiment was conducted to evaluate role of silica against moisture stress. Spring planting of sugarcane (CoLk 11296) was conducted using recommended agronomic package and practices. Silicic acid and silicon dioxide were applied @100 and 200 kg Si/ha as basal dose along with foliar application at 90 and 120 DAP. Germination % and tillering were recorded. Silica @ 200 kg/ha in silica acid form applied as basal dose recorded significantly higher germination (29%) as against control (17%) followed by SiO_2 @ 200 kg/ha (26%). The observation recorded indicates the possible role of silica in modulation of the associated biochemical processes. During the crop growth phase, plant population and biomass accumulation indicated maximum improvement. Tiller numbers,shoot population and biomass dynamicsimproved with silicic acid at higher dose as compared to control. Juice quality attributes such a sucrose (%), purity coefficient and ^{0}Brix were recorded and found to be maximum with silicic acid that indicates the possible role of silicic acid in modulation of sucrose metabolism such as sucrose phosphate synthase, sucrose synthase, invertase and sucrose phosphate phosphatase activity. A pot experiment was also conducted with CoLk 11206 to study the effect of silica on moisture stress. Stress associated physiological and biochemical marker such as relative water content (RWC), electrolyte leakage (EC), soluble protein and enzyme activities such as SOD, CAT and POD showed enhanced activity with silica during

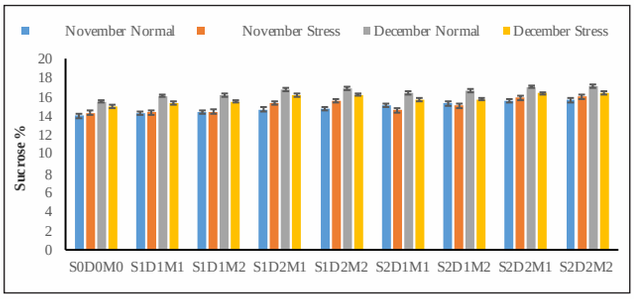
moisture stress as compared to control. Root length and root volume increased with silica under both normal and moisture stressed condition.











Inter-Institutional Research Project: Screening and identification of sugarcane lines tolerant to water-logging and their physio-biochemical investigation

Changes in photosynthetic pigment contents and SPAD index under waterlogging: An effort was made to evaluate changes in photosynthetic pigments, chlorophyll a (Chl *a*), chlorophyll b (Chl *b*), total Chl (Chl *a* + Chl *b*), carotenoids (CAR), the ratio of Chl *a* and Chl *b* (Chl *a*/*b*) and total Chl/CAR ratio and SPAD index in plants grown under waterlogged conditions (WL) along with untreated control (C) using four sugarcane cultivars; CoLk 94184, BO 91, CoS 767 and CoJ 64. The results obtained indicated variation in Chl a, b, total Chl contents (mg/g fresh wt.) among different cultivars and relatively less in waterlogged plants. Chl a ranged between 1.277-2.300 (mean: 1.949 in control) and 1.057-2.150 (mean: 1.716 in waterlogged), Chl b, 0.319- 0.607 (mean:0.518) in control and 0.290- 0.571 (mean: 0.453) in waterlogged plants, respectively. Chl a/b ratio is slightly higher in waterlogged (3.640-3.957, mean: 3.794) as compared to control (3.610-3.997, mean: 3.789) plants except in CoJ 64, while total Chl/CAR ratio was comparatively lesser in waterlogged plants as compared to untreated control. SPAD index was relatively higher in control (30.1 - 35.3, mean: 34.0) than waterlogged plants (22.4-34.1, mean: 29.6) similar to destructive analysis of chlorophyll contents.

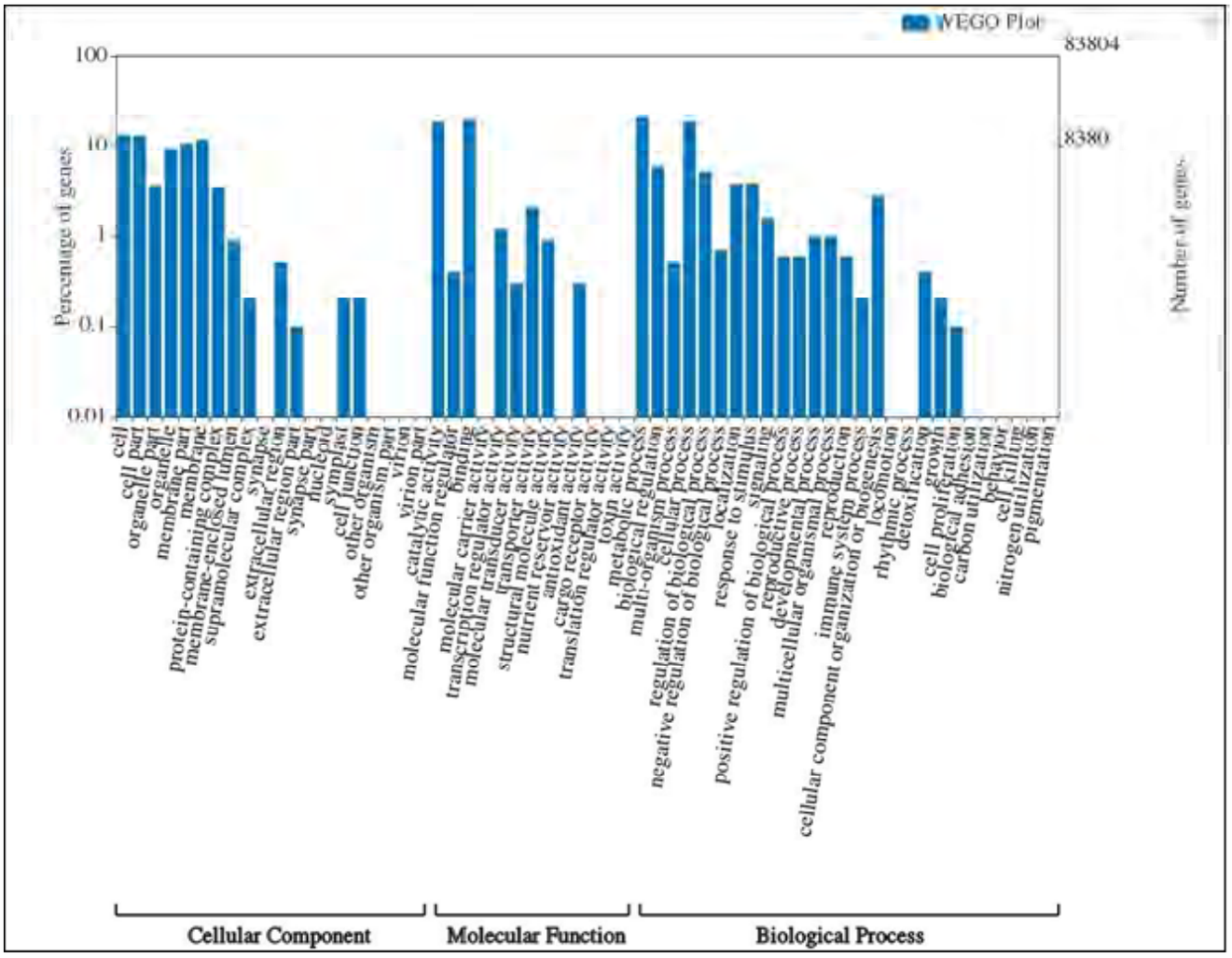


Fig. 4.3. Gene ontology categorization of the unigenes based on the ontologies of cellular, molecular and biological components

Juice quality attributes due to waterlogging: Changes in juice quality attributes (Brix, Sucrose % juice and juice purity) were studied in twenty-four sugarcane genotypes under waterlogged condition along with untreated control in the months of December and January. Results obtained indicated wide variation among genotypes and on mean basis, these attributes were numerically higher due to waterlogging.

Transcriptome analysis: In this study, an Illumina – based comparative differential transcriptomic analysis was performed using leaf samples of two sugarcane varieties; CoLk 94184 and CoJ 64 subjected to waterlogging along with untreated control. Overall, a total of 4,47,196 transcripts were identified with an average length of 509 bp (N50= 621) for the *de novo* assembly of 2,96,518 unigenes with an average length of 529 bp (N50=664) (Table 4.1). Gene ontology (GO) category distribution is shown in Figure 1. Differentially expressed gene were identified in both the varieties under control and waterlogged condition, as per the DESeq R/Bioc package. The total number of genes that showed differential expression were 69,365, 62,339, 70,352, 63,609 in control *vs* waterlogging (CoLk 94184), CoLk 94184 *vs* CoJ 64 (control), CoLk 94184 vs CoJ 64 (waterlogging) and control vs waterlogging (CoJ 64), respectively.

Table 4.1. Length and internal distribution of transcripts and unigenes

Type	Total number	Total length (bp)	Mean length (bp)	Maximum length (bp)	Minimum length (bp)	N50 (bp)	>500bp	>1000bp
Transcript	4,47,196	22,76,61,629	509	15,514	201	621	26,049	46,042
Unigene	2,96,518	15,64,85,793	529	15,514	201	664	18,928	32,471

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

Pre-treatment by di-sulphuric acid of SCT resulted in the increase of fermentable sugar content from 33.8 to 68.0%. The commercial enzyme reagents for saccharification of the SCT were worked upon as a combination of enzymes of Cellulase and Pectinase. The optimum mixing ratio was calculated and the optimised cocktail successfully achieved 67.3 g/L in production of the total fermentable sugar by hydrolysis of acid treated SCT that offered hydrolysis efficiency of 73.1%. SSF of 100 g/L pre-treated SCT with the optimal cocktail and *S. cerevisiae* under aerobic condition resulted in 21.3 g/L ethanol concentration for 36 h. The construction of cellulase cocktail by the proposed statistical method enabled efficient hydrolysis of pre-treated SCT. SSF process combining the optimized cocktail and a xylose-fermenting fungus could be expected as a promising system for ethanol production from SCT.

The construction of cellulase cocktail enabled efficient hydrolysis or pre-treated SCT. SSF process through optimized cellulase cocktail and a xylose-fermenting fungus could prove to be an efficient system for ethanol production from SCT.

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

IBA, 6BA and NAA each along with water, *Ethrel* and absolute control using CoLk 94184 were assessed for both plant and ratoon crops. Significant changes occurred in germination of plant crop, shoot population and biomass accumulation with *Ethrel* as compared to water and control. Maximum sprouting % was found with *Ethrel* @ 100 ppm and NAA @ 50 ppm. Average initial shoot numbers were the highest with *Ethrel* and NAA @ 50 and 100 ppm at 180 DAP. Similar trend was obtained with biomass accumulation across the crop cycle. Number of millable canes (NMC)/ha, single cane weight (g) and cane yield (t/ha) indicated maximum effect of *Ethrel* followed by NAA @ 50 ppm with 1,28,951 and 1,10,550/ha against 95,000 and 83,000 NMC/ha in water and control, cane weight 673 and 547 g against 610 and 510 g in water and control at 330 DAP after harvest. During the plant crop cycle, maximum improvement in germination and biomass dynamics occurred with *Ethrel* as compared to water and control. Shoot numbers and biomass accumulation decreased in order of *Ethrel* @ 100 ppm >NAA @ 50 ppm > water> control till 300 DAP. Cane length, girth, internodal numbers, internodal weight, number of roots, root length, number of root hairs and cane weight showed maximum impact with *Ethrel* followed by NAA @ 50 ppm. *Ethrel* @ 100 ppm and NAA @ 50 ppm reduced MDA and H_2O_2 accumulation and increased POD activity and enhanced the metabolic processes for inducing faster H-A transition.

Technology developed

- PGR technology (Phasic application of Ethrel (@ 100 ppm) and GA_3 (@ 35 ppm at 90, 120 and 150 DAP) application showed higher cane yield (> 120 t/ha).
- Setts priming with ethephon @ 100 ppm causes early (at 20 days) and higher rate of bud germination (approx. 56%) in sugarcane.
- Partial gene sequence of Phosphoenolpyruvate carboxylase (PEPc) of cultivar CoLk 94184, submitted to Genbank and received Accession No. MW766370, Submitted by Radha Jain, A.D. Pathak, A. Chandra and A. Gupta.
- Identified a variety CoLk 94184, the most tolerant to post-harvest deterioration under delayed crushing system and it was highly responsive to BKC+ SMS formulation for minimization of post-harvest sucrose losses in sugarcane.
- Transcriptome analysis of sensitive and tolerant waterlogging lines performed. Total PE reads were 3,62,92,012, 3,40,08,354, 3,50,79,347 and 4,44,66,851 in control and waterlogged plants of CoLk 94184 and CoJ 64, respectively.
- Metagenomic analysis: Microbial diversity of rhizophere soils collected from waterlogged and control plots based on 16S rRNA gene studied: Out of total OTUs picked (1,53,066), 91-92% classified under Bacteria in waterlogged and 94% in control plots and 6-9% unknown species.
- Identified BO 91, CoLK 19184 and CoLK 11206 as water use efficient genotypes.

CHAPTER 5

Mechanization of Sugarcane Farming

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

Two prototypes were developed for carrying out ratoon initiation operations in sugarcane ratoon field. Developed prototypes were tractor operated and performed cultural operations such as stubble shaving, off barring and fertilizer application simultaneously in a single pass in a ratoon field having left over trash. Due to presence of discs for off barring, equipment performed efficiently even in the field having left over surface trash. Developed prototypes were of two types. First was without stubble shaver attachment and only perform off barring and fertilizer application (Fig. 5.1). The second prototype has stubble shaver attachments also to perform stubble shaving along with off barring and fertilizer application (Fig. 5.2). Prototype without stubble shaver is suitable for piecemeal harvesting and also for subsequent intercultural and fertilizer application after ratoon initiation. Field trials were conducted at IISR farm as well as farmers field to evaluate the performance of the developed machine. Machine performed well during field trials. Uniform and synchronized tillering was observed after stubble shaving operation. Effective field capacity of the machine was 0.30-0.35 ha/h.

Fig. 5.1. Two row Disc RMD without stubble shaving attachment

Fig. 5.2. Two row Disc RMD with stubble shaving attachment

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

The prototype of developed multipurpose tool frame with attachments for furrow opening, interculturing and earthing up was demonstrated at farmers' field in more than 8.84 ha area in Biswan Sugar mill area of Sitapur (Fig. 5.3). All attachments of the tool frame can be adjusted for 75 or 90 cm row spacing of sugarcane. The IISR designed deep furrower were used as an attachment for furrow opening and earthing up operations. The interculturing attachment having tines with shovel and sweep were used for inter-row interculturing. The capacity of the machine was 0.48 ha/h for inter-row interculturing with 78% field efficiency. The interculturing tool having sweep in between two shovels left no soil untilled but cultivator having only shovel left untilled soil in between shovels. Hence, the weeding efficiency in case of cultivator was 10-15% lower as compared to the developed attachment. The earthing up and furrow opening attachments have better performance as compared to conventional ridger in term of higher depth of furrow and ridge height. There was saving of about 50-60% in cost of operation and 90-95% in labour requirement with the developed equipment when used for combined operation of inter-row interculturing, intra-row weeding through herbicide spraying and fertilizer application as compared to conventional practice of using tractor operated cultivator for inter-row and manual hoeing for intra-row weeding with manual broadcasting of fertilizer. The farmers were very much convinced with the performance of the multi-functional tool frame for sugarcane cultivation.

Fig. 5.3. Demonstration of IISR multipurpose tool frame at farmers' field in Biswan

Development of cane node planter

Tractor operated cane node planter was developed (Fig. 5.4). Cane node metering mechanism was modified. Spring loaded pusher was developed and incorporated for efficient metering of cane nodes during planting. Planter 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. Effective field capacity of the planter was 0.15-0.17 ha/h. Prototype of manual cane node cutter was also developed for cutting of cane nodes from whole seed cane (Fig. 5.5).

Fig. 5.4. Tractor operated cane node planter in field operation

Fig. 5.5. Manual cane node cutter

Development of sugarcane trash management machinery

The new prototype machine was fabricated which will cover two rows of sugarcane. The stubble shaving unit will operate after the trash shredding operation. It is equipped to chemical spraying unit as well for applying trash decomposer for its faster decomposition. The equipment comprises a main frame to mount the trash mulching unit, chemical spraying unit and elongated frame for mounting stubble shaving unit. The trash mulcher unit further comprising of differential diameter axle and cutting blade mounted thereon, having top cover and an aperture on rear side disposed there between adapted to receive a wingspread adjustment mechanism there through to facilitate the de-clogging of the crop residue. The front cover comprising with rubber flaps provide aperture for trash to move in for shredding.

The tractor PTO power is utilized to operate the machine. The reduced rpm through gearbox is transmitted by belt and pulley power transmission system to trash mulcher and stubble shaver. The rear roller ensures uniform depth control while covering two rows of sugarcane and trash in between the rows. The frame is elongated and extends in a horizontal direction away from the main frame to support the two stubble shavers. The stubble shavers are surrounded by three sides with rubber flaps to provide safety from pebbles and chopped cane pieces cut by stubble shavers. The stubble shaving unit further comprising of two stubble shavers consisting of concave discs with replaceable serrated cutting blades mounted on disc periphery. The discs were mounted on a rigid and rugged mild steel frame with the help of couplings made of circular steel plate and hollow shaft. Disc blades were provided tilt in the forward (suction angle) that caused suction for sharp shaving/cutting of stubbles without splitting and clogging.

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

Ergonomic evaluation of sett cutting at IISR farm

The ergonomic evaluation of conventional practices for sett cutting manually with cutting knife have been carried out at the Institute farm. Five individual males and females were selected for sett setting by the conventional practices who have the experience of sugarcane field operations/practices for more than five years. The data of sett cutting by the cutting blade was taken for 20 minutes continuous work by the operator. The detailed specification of the cutting knife is presented in Table 5.1. The number of sett cut by the male and female operator varies as per the sugarcane variety (Fig. 5.6).

Table 5.1. Specification of the cutting knife used for sett cutting

Weight, g	335
Thickness, mm	1.0
Material of blade	Mild steel
Dimension of the hand grip, mm	150 x 60 x 18
Thickness of the cutting edge, mm	0.8
Effective cutting length of the blade, mm	220
Material of handle	Plastic
Overall dimensions, L x B, mm	480 x 90

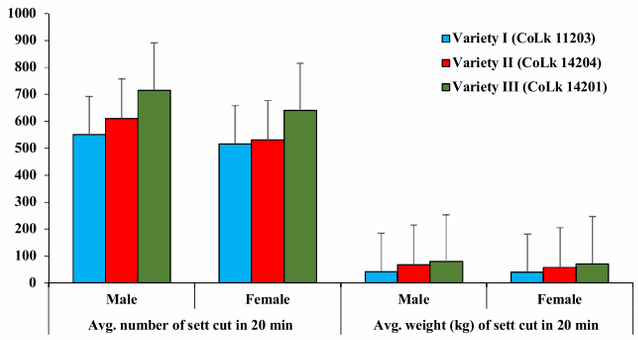


Fig. 5.6. Average number and weight of sett cut by the operator

Fig. 5.7. Sett cutting by male and female farm worker

The increase in working heart rate and energy expenditure rate of female farm worker for sett cutting was observed 21% and 20% more, respectively than male workers with corresponding overall discomfort rating of 6.5 and 5.6 (Table 5.2).

Table 5.2. Result of ergonomic evaluation of sett cutting

Parameter	Cutting knife	
	Male	Female
Working heart rate (beats/min)	102.8	107.6
Δ Working heart rate (beats/min)	28.4	34.2
Oxygen consumption rate (l/min)	0.491	0.546
Δ Oxygen consumption rate (l/min)	0.323	0.389
Energy expenditure rate, EER (kJ/min)	10.29	11.44
Δ Energy expenditure rate, kJ/min, (Δ EER)	6.78	8.16
Overall discomfort rating (ODR)	5.6	6.5

Inter Institutional Collaborative Research Project on Testing and evaluation of selected IISR sugarcane machineries under tropical condition

(i) Deep furrow sugarcane cutter planter

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

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

Fig. 5.8. Developed prototype of tractor operated wide spaced deep furrow sugarcane cutter planter

Fig. 5.9. Planting with IISR - Two row deep furrow sugarcane cutter planter in field at ICAR-SBI, Coimbatore farm

(ii) Disc type ratoon management device (Disc RMD)

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. Performance trials of the planter are in progress at ICAR-SBI farm. Efforts are being made to commercialize the machinery.

Fig. 5.10. Developed prototype of tractor operated disc type ratoon management device (Disc RMD)

Fig. 5.11. Ratoon management using IISR-Disc RMD in the field at ICAR-SBI, Coimbatore farm

UPCAR Project: Centre of excellence in farm machinery

Development and testing of manual multicrop planter

The prototype of developed single row manual multicrop planter was field tested and demonstrated at farmers' field and at IISR Farm in about 14.44 ha area in different villages of Sitapur and Lakhimpur Kheri districts of Uttar Pradesh in the months of February, October and November 2021 for sowing of Okra, black gram, chickpea, lentil, pigeonpea, mustard and peas mainly as intercrop in sugarcane. 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 lentil, chickpea and peas, every grooves/cell picks only one seed and drops it perfectly. However, in case of mustard, the seed rate was little bit high. The effective field capacity of the machine was 0.08-0.11 ha/h with field efficiency of 62-66%. Farmers were very much convinced and appreciated this manual machine for sowing of intercrops in sugarcane and for general line sowing of crops. Five number of manual multicrop planter was fabricated in the workshop for multi-location trials and demonstrations at farmers' field. Thirty four frontline demostrations of manual multicrop planter were conducted on chickpea, lentil, urdbean and okra on 14.44 ha area.

Fig. 5.12. Demonstrations of Manual Multicrop Planter in villages of Biswan sugar mill area

Fig. 5.13. Operation of Manual Multicrop Planter at IISR Farm

Development of bird scaring device

A prototype of battery operated and wind assisted bird scarring device was developed. It is an audible bird/animal scaring device that uses noise stimuli which makes birds/blue bull uncomfortable. Instead of using a visual method to distract birds/wild animals, it uses the sound of a heavy iron bolt repeatedly and regularly hitting or banging a steel disc producing an annoying noise to dislocate birds from entering the farmer's field and prevents newly grown crop seedlings from being eaten and destroyed.

However, once birds realize these pose no real threats, they can easily become habituated to sounds that seemed initially frightened. So, different type of sounds were needed to avoid the birds/animal to become habitual. This bird scaring device was an electronic audible bird scarer that consisted of dry battery (12 V, 7 Amp.), solar panel (20 W), speed controller, delay timer, DC motor, propeller and different steel discs. The battery was used

Fig. 5.14. Bird scaring device installed at the farm

to supply current to the DC motor. A thin light and narrow flat of 8 inches was mounted on the motor shaft perpendicularly by its centre. The end of the thin flat has one hole on each end. A small loose iron wire was tied to an iron nut that hangs through gravity.

The battery was connected to a speed controller which regulates the speed of the DC motor. A delay timer was also provided between battery and controller. A plain steel disc was mounted just below the iron bolts connected to the flat mounted on the motor shaft. When the power was turned on, the shaft along with the flat starts rotating and hanging nuts continues to rotate in circular motion and starts hitting on the steel disc rapidly producing a loud banging noise which makes the birds frightened and dissuade them away from eating recently planted crops. One 20 W solar panel was also attached to the bird scaring device to charge the battery during day time.

An additional arrangement was also provided with this assembly to produce the same audible scaring noise through natural wind only. Whenever a moderate speed wind blows, the propeller automatically starts rotating and moving the hanging nuts to rotate in circular motion and rapidly banging the steel disc creating an uncomfortable noise for birds/animals.

Development and testing of pedal operated paddy thresher

The developed prototype of pedal operated paddy thresher was tested for threshing of paddy crop at Institute Farm (30 hours) as well at three farmers' field (for 25 hours) in Lucknow and Sitapur districts. One person operates the machine easily by putting all crop to be threshed in a heap near the machine. The capacity of the machine was 60-85 kg/h with threshing efficiency 96-98%.

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

Fig. 5.15. Evaluation of the pedal operated paddy thresher

Development of motor operated paddy thresher

A prototype of motor operated paddy thresher was developed for threshing of paddy crop. Two persons can perform threshing operation on this machine at a time. It consists of wire-loop type threshing drum, power transmission system, polycarbonate sheet body and wheels for transportation. The threshing drum consists of wire-loops of 'U' shape, embedded in metallic strips. A shaft carries the threshing drum and is connected to the single phase AC motor (0.373kW) through V pulley and V belt. On operating the motor, the drum starts rotating. For operation, paddy bundle is held in hands and earhead portion of the crop is placed on the rotating drum. The wire-loops hit the earheads and grain get detached from the rest of the crop. There is a grain loss protecting cover. The machine has provision of small three ground wheels (one free wheel) to help during transportation from one place to another by pulling with the help of handle but while operation of threshing these wheels has to be lifted/adjusted by just removing one split pin and bolt. The machine has provision of winnowing fan for winnowing the paddy grains. A handle is also provided for operating the machine through hand cranking in case of non-availability of electric power. In that case, one person is required to operate the thresher with the handle.

Table 5.3. Technical specification of motor operated paddy thresher

Parameter	Values
Length x width, mm	1350 x 780
Length of drum, mm	1250
Diameter of drum. mm	280 (without pegs) 400 (with pegs)
Height of pegs, mm	50
Power source	Motor (0.373 kW) & manual (by handle)
Winnowing fan	4 blades (60 cm length)

AICRP on Farm Implements and Machinery

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

Prototypes fabricated

Machine/Implement	Source of power	Achievement (No.)
TO Deep furrow sugarcane cutter planter	Tractor	3
TO trench opener	Tractor	2
TO Deep furrower	Tractor	1
TO Disc type sugarcane management device	Tractor	1
TO Raised bed seeder	Tractor	1
Manual cane detrasher	Manual	10
Manual cane bud scooper/ chipper	Manual	-
Manual cane node cutter-cum-bud scooper	Manual	70
Manual grass cutter	Manual	20
Manual multi-crop seed drill	Manual	5
Total		**113**

Prototypes supplied

Name of prototype	No.	Supplied to
IISR TO deep furrow sugarcane cutter planter with marker attachment	2	Sugarcane Research and Seed Multiplication Centre, Gola, Kheri (UPCSR, Shahjahanpur)- 1 No.
IISR TO deep furrow sugarcane cutter planter with marker attachment		Sugarcane Research and Seed Multiplication Centre, Katya, Sadat, Ghazipur (UPCSR, Shahjahanpur)- 1 No.
IISR TO trencher	1	Sh. Durga Prasad Maurya, Pihar, Sagadi, Azamgarh
IISR Manual cane detrasher	5	Sh. Ganesh Prasad Dubey, Georgetown, Prayagraj
IISR Manual bud chipper	1	*Ganna Vikas Parishad*, Jarwal Road, Bahraich
IISR manual cane node cutter-cum-bud scooper	1	Sh. Bhanesh Mani Tripathi, Vill- Khalilpur, Chhittaura, Bahraich
IISR manual cane node cutter-cum-bud scooper	10	UP State Sugar and Cane Development Corporation Ltd Munderwa, Basti
IISR manual cane node cutter-cum-bud scooper	40	UP State Sugar and Cane Development Corporation Ltd., Pipraich, Gorakhpur
IISR manual cane node cutter-cum-bud scooper	1	KVK, Basti
IISR manual cane node cutter-cum-bud scooper	2	Sh. Kaushal Kumar Mishra, Ganganagar, Kaanth, Shahjahanpur
IISR manual cane node cutter-cum-bud scooper	1	KSCM Mahmoodabad, Sitapur
Total	**64**	

2. Prototype feasibility testing

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

Prototype feasibility testing of tractor operated automatic potato-cum-sugarcane trench planter was conducted in one ha area at IISR farm. Prior to actual field testing of the developed equipment, it was calibrated in the field for different metering mechanisms and necessary adjustments were made. Field testing of the planter was conducted in sandy loam soil at IISR farm. It performed planting of single paired rows of sugarcane in trench furrows and two rows of potato on ridges simultaneously. At forward speed of 0.5 m/s, mean overlapping between two successive setts were 68 mm, which was within the desired overlapping range of 50-100 mm for the study area. The average spacing between seed potato tubers was 192 mm. Missing of seed potato tubers in the cups of metering unit was 7.1%. Picking of more than one seed potato tubers was 5.4%. Missing and multiple picking of seed potato tubers complemented each other and therefore, desired seed rate was maintained. The slight variation due to missing and multiple picking did not affect the uniformity of the crop stand.

Fig. 5.16. Automatic potato-cum-sugarcane trench planter under field operation

Theoretical field capacity of the planter was 0.27 ha/h. Time lost in filling of seed, insecticide solution, turning, miscellaneous settings and other activities in terms of total planting time was 47 per cent of total operating time. It was observed that maximum time was lost in filling of inputs followed by turning of the tractor. The effective field capacity of the planter was 0.127 ha/h. Thus to plant one hectare area, it would take approximately 8 hours time. The cost of planting operation with developed planter was ₹ 3,160/ha whereas it was ₹ 13,600/ha when planting was done manually. Thus, there was 76.8% cost saving in planting with developed machine. The labour requirement with planter was significantly low as compared to manual planting. It required 56 man-h/ha to plant with developed planter whereas manual planting required 567 man/ha. Thus, saving in labour by planting with developed machine was 90.1%.

Prototype Feasibility Testing of Pedal operated paddy thresher

Prototype Feasibility Testing of Pedal operated paddy thresher was conducted at the Institute Farm as well as at farmers field of Lucknow and Sitapur districts. It was operated for 25 hours at Institute farm and 30 hours at farmers 'field. The performance of the thresher was compared with the conventional practice *i.e.*, beating the paddy bundle on stones or wooden platform in bending posture in term of threshing capacity, threshing efficiency and energy requirement under different moisture content and stalk length. Machine was operated by both male and female workers. The total man-h requirement was recorded for threshing under different moisture contents and stalk lengths of the bundles for further conversion into energy equivalents.

The paddy thresher was evaluated for three different rice varieties in conventional and developed pedal thresher in three replications. Three variables, variety (V), moisture content (M) and stalk length (L) were used for investigation. Performance of the thresher was evaluated in respect of three parameters namely threshing capacity, threshing efficiency and energy requirement.

Fig. 5.17. Pedal operated paddy thresher in operation

CHAPTER 6

Diversification and Value-addition in Sugarcane

Refinement of sugarcane cleaner cum washer for jaggery

Capacity of sugarcane cleaner-cum-washer was increased by replacing 1 h.p. motor by 2 h.p. motor for accommodating more canes. This along with increasing speed of upper roller of second set of scrapping rollers considerably increased machine's capacity. The target was to get a capacity of 1,000 kg/h matching with sugarcane crusher being used in Jaggery Unit. Water spraying system is also to be modified. Two separate small submersible pumps would be used for spraying water at two different points for washing of canes. The machine is to be covered with MS sheet and only inlet and exit points would be open.

Development of IISR model jaggery unit for enhanced capacity

The unit was evaluated for its performance by preparing three batch of jaggery on the basis of total consumption of bagasse, total time consumption, water evaporation rate during the jaggery preparation. The overall consumption of bagasse per batch was 230 kg for production of 95 kg jaggery from 600 kg juice. The thermal efficiency and jaggery production efficiency of the furnace was estimated as 29% and 16%, respectively.

Development of small powder jaggery cubes

A manually operated machine for making jaggery cubes using jaggery powder was developed. Experiments were conducted using the graded jaggery powder of fineness (less than 0.300 mm), having a moisture content of 7.0 ± 0.3. The capacity of the machine was 840 jaggery cubes per hour or 5.04 kg/h, each cube weighing 6 gm. The average compression ratio of jaggery cubes was 2.825. The average value of density of the jaggery cubes was 1.65 g/cm^3.

AICRP on Post-Harvest Engineering Technology

Comparative quality assessment of the jaggery prepared by sugarcane cultivated through chemical pesticide (Clorantraniliprole) and herbal formulation

Technical programme has been finalized. Three sugarcane varieties (Co 0238, CoLk 94184 and CoLk 09204) have been selected for the study. The planting was done on November 01, 2021 with IISR recommended practices. Observations regarding germination, tillers and weed intensity are being recorded.

Evaluation and transfer of sugarcane-based technologies/process developed by other centres

Granular jaggery machine from Anakapalli centre and sugarcane juice preservation technology from TNAU centre and Solan centre will be evaluated. The purchase procedure for procurement of machine is in progress.

Externally funded projects

DST funded project on "Modified atmosphere packaging of sugarcane juice in closed system"

Purchase of CO_2 analyser for the study has been completed. Kinetics of PPO activity in sugarcane juice has been done. Modified atmosphere chamber for the study has been developed.

RKVY funded project on Establishment of quality jaggery production cum training units in selected districts of Uttar Pradesh for income generation and entrepreneurship development

Four units have been established and two units at KVK, Meerut and KVK, Muzaffarnagar were under construction.

RKVY funded project on Establishment of IISR model jaggery unit at KVK, Lakhimpur Kheri for entrepreneurship development and income enhancement of sugarcane farmers

Establishment of IISR model jaggery unit at KVK, Lakhimpur Kheri has been initiated and tendering process is in progress.

NAIF funded project on Establishment of Agri-Business Incubation Centre at ICAR-IISR, Lucknow under National Agriculture Innovation Fund

MoA has been signed with incubatee for value added products from jaggery. Food processing laboratory was renovated. A new jaggery unit is being established. Creation of Agri Business Incubation Centre office is in progress.

UPCST funded project on Development of process technology (protocol) for manufacturing of protein rich jaggery using natural source

During first- and second-year, soybean was added in powder and paste form (with and without seed coat) in different quantities. Quantity of soybean was kept same in powder and paste form. Soybean to water ratio was kept as 1:3 for making smooth paste. 50, 100, 150 and 200 g soybean was used per 10 litre of sugarcane juice and accordingly paste was used. Protein content of jaggery increased with increase in soybean content either in powder or paste form. Jaggery samples having large quantity of soybean (200 g) either in powder or paste form (with and without soybean) did not set well. Out of different samples, samples with soybean paste without seed coat were found to be better and the protein content ranged between 4.56 and 7.03%. However, protein content of 7.03% was found with 200 g soybean and this sample posed problem in setting along with all other samples with same quantity of soybean. Hence, such a large quantity of soybean was discarded for further experimentations. Based on other quality parameters, soybean content of 100 and 150 g for using in paste form without seed coat was selected for further experimentation. Thus, samples have been prepared and kept for further observation.

Protein content in different jaggery samples is shown in Fig. 6.1.

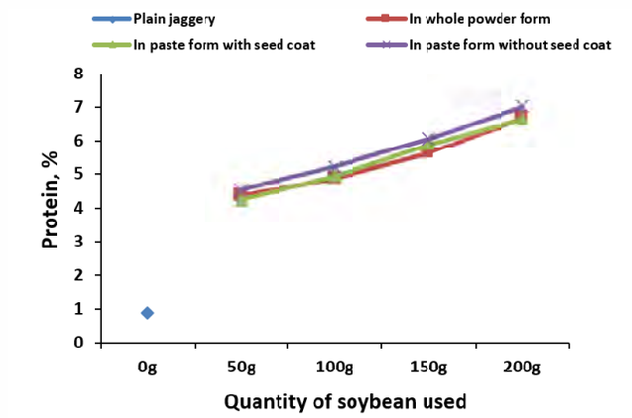


Fig. 6.1. Protein content in different jaggery samples

CHAPTER 7

Developing Sugar Beet Varieties for Indian Agro-climates

Seed production and maintenance of sugar beet germplasm at Sugar beet Breeding Outpost, Mukteshwar

One thirty-nine sugar beet germplasm are being maintained and evaluated at Sugar beet Breeding Outpost, Mukteshwar. The seeds of varieties LS 6 and IISR Comp. 1 are being produced for need-based supply to the sugar beet growers of the country. Seeds of indigenous LKC 2020 (better ethanol recovery under water limiting condition), LKC 2000 (improved juice quality under post-harvest technology), LKC LB (fodder purposes with low brix), LKC 2006, LKC HB, LKC 2007 (water deficit tolerant), LKC 2020-1 (*Spodoptera litura* resistant) are being produced for experimental purposes. In the month of September 2021, fresh seeds of 74 sugar beet varieties and germplasm were produced at Sugar beet Breeding Outpost, Mukteshwar. Genetic resources of sugar beet are being preserved in cold storage at ICAR-IISR, Lucknow and every alternative year, the seeds are freshened.

Preservation of sugar beet genetic resources in cold chamber

Sugar beet breeding

Four new crosses, *viz*., IN 17 × LK 4, LK 0501 × LS 6, LK 9503 × LS 6, LK 0503 × LK 27 of inbred lines were attempted in order to generate indigenous types for the Indian sub-tropical climate at Sugar beet Breeding Outpost, Mukteshwar. Testing of these inbred lines through data recordation will be performed in April 2022.

Morphological assessment of sugar beet grown under water limiting conditions

An experiment was established with 14 genotypes including two checks in three replications with the aim of identifying better performing sugar beet genotypes under water limiting conditions. Drought imposed by withdrawal of irrigation and regularly monitored. Meanwhile, irrigated plot was well saturated with proper irrigation. The genotypes, LKC 2006, LKC HB and LKC 2007 had maintained superiority for single root weight, length, and the diameter under both environments (Table 7.1).

Table 7.1. Performance of genotypes under irrigated (E_1) and drought (E_2)

Variety	Single root weight (kg)		Sucrose (%)	
	E_1	E_2	E_1	E_2
LKC 2007	2.25	1.18	19.12	17.30
LKC 2006	2.02	1.10	18.26	17.72
LKC HB	1.95	0.91	20.35	17.89

Screening of diseases and insect pests in sugar beet

A trial of fifty-six sugar beet germplasm was conducted to screen the diseases and insect pests under natural conditions at ICAR-IISR, Lucknow farm. In major foliar diseases, higher prevalence of *Alternaria, Cercospora,* and *Phoma* spp., were recorded, causing leaf spot diseases. Incidence of viral infection in most of the sugar beet varieties was observed. This may be due to transmission *via* aphid, particularly *Myzus persicae*.

Periodical observations of all insect pests and casual visitors with their predatory agents were assessed in fifty-six sugar beet germplasm at ICAR-IISR, Lucknow. *Spodoptera* spp. (Army worm) was most frequently found and caused considerable damage to the crop. The incidence of *Spodoptera* spp., began after two months of germination. The variety LKC 2020-1 showed considerable resistance to *S. litura*. The higher incidence rate of *Spodoptera* (80-95%) during April to May completely damaged the foliar portion of sugar beet. Molecular identification revealed that collected specimens were *Spodoptera litura*. The first minor infestation of pink borers was observed in the crown of sugar beet leaves. Minor incidence of leaf minor, spiders, beetles, and *Myzus* were also observed during February to April.

***Spodoptera* spp. affected sugar beet plant**

Weed identification in sugar beet and new initiatives

Trash mulching through paddy straw was initiated in sugar beet to culminate the weed growth. *Chenopodium album* was found to be the most common weed in sugar beet fields.

Paddy trash in sugar beet fields for weed control

Experimental planting of sugar beet trial for the next season

The experiment is established with 14 germplasm and 2 checks with the objective of evaluation of sugar beet germplasm under water limiting conditions. Three research institutes have received the same set of materials in order to generate data on a variety of subjects. Fifty- six germplasm is sown for screening of disease and insect pests under natural conditions. Planting of 53 germplasm for seed production was done *via* transplanting method at Sugar beet Breeding Outpost, Mukteshwar.

Sugar beet and sugarcane intercropping

Intercropping of sugar beet (LS 6) with sugarcane (CoLk 14201) and four indigenous germplasm, *viz*., IISR Comp 1, LS 6, LKC 2000 and LKC 2020 are sown for demonstration purposes.

Screening of the germplasms planted under field conditions

A total of eighty-seven germplasms of sugar beet were screened against foliar disease incidence. The major diseases observed during the period were *Phoma* leaf blight, *Alternaria* leaf spot, *Cercopsora* leaf spot, *Fusarium* yellows and viral disease complex. Among the eighty-seven germplasm, more than 60 were moderately resistant to the foliar diseases. The diseased leaf samples were observed under microscope for presence of pathogens which was confirmed through the conidia of *Alternaria* sp, *Fusarium* sp, *Phoma* sp. and *Cercospora* sp. These samples were cultured for isolation of pure culture of the fungal pathogens. Among these isolated pathogens, three isolates have been identified as *Alternaria alternate* by the Indian Type Culture Collection, ICAR-IARI. The symptom, pure culture and conidial pictures have been shown below:

***Alternaria* disease symptoms on beet root leaf(A), Pure culture of as *Alternaria alternate*on Oat Meal Agar Media (B) and Club shaped conidia with horizontal and vertical septation (C)**

Analysis of the molecular genetic diversity in sugar beet genotypes using SRAP markers

SRAP markers were employed to investigate the genetic diversity and relationships of sugar beet genotypes in order to select parents for breeding programmes accurately, to improve breeding efficiency and to identify target genotypes quickly. Genomic DNA was isolated from fifty-seven sugar beet accessions, including monogerm lines (including male sterilities and maintainers), polygerm tetraploids, polygerm diploids, F_1 of monogerm cross combinations and foreign varieties using modified CTAB method and amplified using SRAP primer pairs. A total of 304 amplicons of distinct molecular weights ranging from 66 to 600 bp were resolved with 261 completely parsimonious bands having 86.22% polymorphism. In the UPGMA dendogram based on the Euclidean algorithm, these genotypes were clustered into two main groups with 26 and 31 genotypes each. It was observed that SRAP marker were effective for evaluating the variation in genetic components between and within sugar beet accessions.

CHAPTER 8

Economics, Statistics and ICT

International sugar trade and export opportunities for Indian sweeteners

Global sugarcane production was highly concentrated amongst the major ten producing countries, accounted for about 83 per cent of aggregate output during TE 2020. Brazil was the major producer of sugarcane with a share of 39.2 per cent, followed by India (20.1%), Thailand (5.95%), China (5.65%), Pakistan (3.72%), Mexico (2.95%) and Australia (1.67%) during TE 2020. As per Food and Agriculture Organization (FAO) data, world sugarcane production during the year 2020 was 1920 million tonnes which was 2.7 per cent higher as compared to last year sugarcane production. The dynamic sugarcane production scenario in leading producing countries during past four decades has been illustrated in Fig. 8.1. Brazil has consolidated its production position and has increased its share from 18.2 per cent in TE 1980 to 39.2 per cent in TE 2020. The contribution of India in global sugarcane production has declined marginally from 23 per cent in TE 2000 to 20 per cent in TE 2020. China, Thailand and Pakistan have improved their share in world sugarcane production. The share of Australia, USA, Philippines, Mexico and Cuba in the world sugarcane production has declined during past four decades.

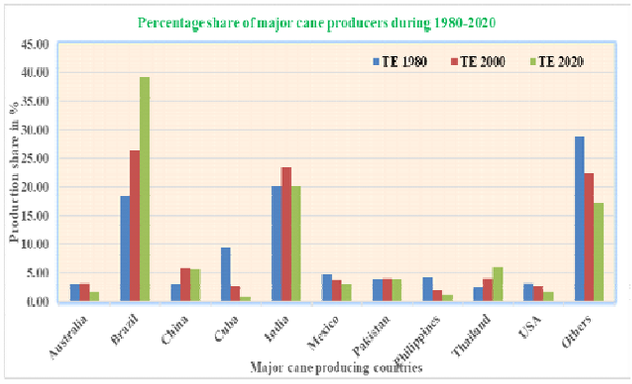


Fig. 8.1. Changing scenario of sugarcane producing nations

The global sugar trade is the most distorted commodity as majority of leading sugar producing nations subsidize their crop production and integrated sugar-energy processing industries to safeguard its economic interest. However, majority of sugar deficit countries or net sugar importers protects domestic producers through extraneous sanitary and phytosanitary measures; trade barriers such as Tariff Rate Quotas (TRQ) and higher import duties *etc.* Therefore, the exporting countries including India provides sugar export subsidies to increase sugar export and to optimize opening sugar stock. The sugar mills have to generate sufficient money to pay cane price payment to the farmers. The Government has allocated sugar export subsidy which was directly transferred to the sugarcane farmers' accounts for cane price payment by the sugar mills. India also benefited with sugar export as global prices shows upward trend. The sugar production declined in Thailand and other Asian countries which provides an opportunity for India to export more quantity to its logistic suitable traditional markets such as Sri Lanka, Iran, Indonesia, Middle East and Malaysia. In spite of Covid-19 pandemic, India had exported 104.4 LT sugar during 2021 (Fig. 8.2 and 8.3). Indian sugar and traditional jaggery has high demand from Indonesia, Bangladesh, Sudan, UAE, Somalia, Djibouti, Sri Lanka, Saudi Arab, Malaysia, Afghanistan, Nepal, Iraq *etc.* India has surplus sugar as its production was more than the domestic market demand during last six sugar seasons. The sweeteners export surge is

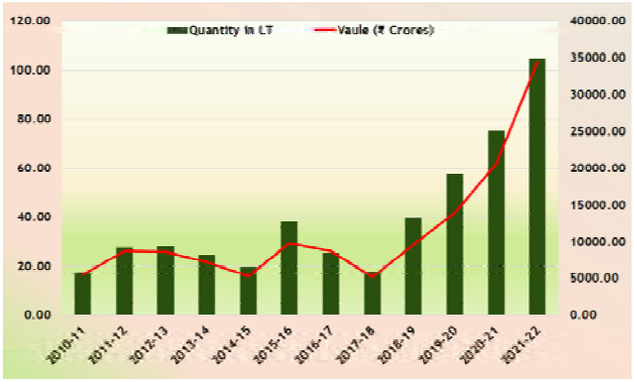


Fig. 8.2. Sugar export from India during 2011-2022

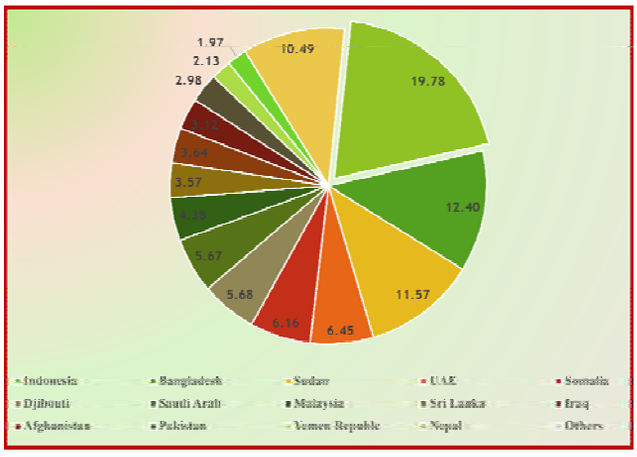


Fig. 8.3. Major export destination for Indian sweeteners during 2021

primarily due to firm international sugar prices which have made the foreign markets much lucrative.

Brazil was the largest sugarcane producing county with a share of 40.4 per cent of world sugarcane production, followed by India 18.5 per cent in TE 2020. China (5.6%), Thailand (5.3%), Pakistan (5.0%) and Mexico (3.0%) are other notable sugarcane producing countries globally. Brazilian sugar production was nearly 32 million tonnes as compared to 38 million tonnes during year 2019-20. Thailand sugar production has also come down from 12 to 7.7 million tonnes. It helps Indian sugar to move forward to global markets.

Indian share in world sugar exports has increased from 3.5 to 7.5 per cent during 2017-18 to 2020-21. Now India has become third largest sugar exporter globally. The policy and other favorable measures for sugar export promotion are as follows:

The sugar export of India was canalized under provisions of sugar export promotion Act, 1958 through notified export agencies, *viz*,. Indian Sugar & General Industry Export Import Corporation Ltd. (ISGIEIC) and State Trading Corporation of India Ltd. (STC). However, Sugar export promotion Act, 1958 was repealed in 1997. The sugar export was de-canalized and permitted subject to obtain Registration-cum-Allocation Certificate (RCAC) from Agricultural and Processed Food Products Export Development Authority (APEDA). Since 2001, requirement of RCAC was dispensed with and sugar exports were allowed by the sugar mills/merchant exporters after obtaining the export release order from Directorate of Sugar, Ministry of Consumer Affairs, Food and Public Distribution, Government of India. The export subsidies were offered to increase sugar export for optimizing opening sugar stock and help sugar mills in generating financial liquidity to pay sugarcane price arrears to farmers. The subsidy offered by Govt. of India aids sugar export of 7.51 million tonnes during the year 2020-21. Indian sugar mills benefited with sugar export as global prices had upward trend as sugar production declined in other major sugar exporting nations such as Brazil and Thailand. It gives an opportunity to India to export sugar to its logistical advantages traditional overseas markets.

- Though India has become a net sugar exporter during past decade. There are wide fluctuations in quantity exported as it depends on sugar production, international price, domestic demand and supply scenario. India's sugar exports were the highest (104.4 lakh tonne) in 2021-22 and the lowest (17.4 lakh tonne) in 2010-11. India became a net sugar importer during the year 2017-18 due to significant fall in domestic sugar production. The surplus sugar production and its demand supply mismatch in domestic markets responsible for low sugar prices. It is vital to formulate appropriate policies to enhance sugar export; find ways and means to identify the neighbouring countries sugar market where India has logistic advantage to rationalize supply and domestic sugar prices. The major sugar export destinations for India were Indonesia, Bangladesh, Sudan, UAE, Somalia, Djibouti, Sri Lanka, Saudi Arab, Malaysia, Afghanistan, Nepal, Iraq *etc.* The share of sugar exports to these counties has improved a lot during the second decade of 21st century.
- The surplus sugar production during last 5-6 crushing seasons and huge previous year carryover sugar stocks, the Govt. of India has initiated various policy initiatives to facilitate sugar exports and improve profitability and sugar industry liquidity. These interventions have kept domestic prices in many countries artificially high in comparison to the world prices. However, some sugar importing countries to protect their industries and domestic markets, use trade policy instruments *viz*., high out-of-quota tariffs (China), adjustment to TRQ of WTO and export limit for Mexico (United States), export subsidies to protect domestic sugar prices (Pakistan), high import tariffs (EU, Russia, USA), regional agreements like North American Free Trade Agreement (NAFTA), European Economic Partnership Agreements (EPAs). Due to Covid-19, pandemic and lockdown in majority of states, domestic sugar consumption has not increased significantly. Therefore, sugar mills have to divert B-heavy molasses for bioethanol production and optimize sugar production to maintain profitability and financial liquidity. To safeguard, economic interest of sugarcane farmers and sugar mills, the other steps taken by the Government are as follows:
- The record higher sugar production and surplus carryover stocks during 2020-21 and ongoing sugar crushing season 2021-22, the Govt. of India have initiated various policy and financial initiatives for facilitating sugar export to improve liquidity of Indian sugar sector. The Govt. of India has fixed sugar export targets by allocating mill-wise MIEQ of 90 lakh tonnes sugar export.
- A comparative analysis of domestic wholesale prices of refined sugar (Mumbai) with international prices of refined sugar traded at Intercontinental Exchange (ICE) in London daily market during year 2014-2021 reveals that India's domestic prices of sugar have been higher than world prices and followed the international prices trend. However, after that domestic prices have registered a sharp increase conflicting to international refined sugar prices showed a diminishing trend. There was sharp decline in international prices as compared

to the domestic sugar prices. It led to huge gap between domestic and international prices, which need to increase in import duty from 40 to 100 per cent to confine sugar imports and boost domestic prices. The domestic sugar prices are nearly 50 per cent more than the international sugar prices during 2019-20, which had declined to 24 per cent in third quarter of 2020 onwards. The study observed that there was higher price volatility in international sugar prices as compared to domestic sugar prices during 2014-2021. Although India is the third largest sugar exporter in the world, it has low reliability as regular sugar exporter. Therefore, India still a relatively small player in global sugar market. It has minute impact on global sugar prices. India's share in world sugar export was 7.5 per cent as compared to giant players such as Brazil and Thailand.

- World sugar prices were low which makes Indian sugar export economically unviable. It does not have comparative advantages in sugarcane production cost in comparison to global leading producing countries.

Impact of IISR technologies in sustaining sugarcane production in India

The impact of four identified technologies has been carried out. Impact assessment of IISR developed sugarcane cutter planter revealed that the returns to research due to sugarcane cutter planter were estimated at ₹ 35.1 per rupee invested in research. The monetary contribution of the machine due to labour saving (in terms of the extent of cost reduction in sugarcane cultivation) was estimated to range from ₹ 150 to ₹ 180 crores per annum. It has an impact on labour displacement. The use of this planting machine results in the saving of 25-35 mandays per ha in the planting of cane, and the aggregate saving of labour days has been estimated around 45.20 lakh mandays at national level. The annual economic gains due to cultivation of CoLk 94184 were worked out at ₹ 400 to ₹ 510 crore per year during 2016-17 to 2019-20 in sub-tropical region, out of which around 24% accrued to growers by way of higher prices and 76% to sugar mills in terms of higher recovery. The returns per rupee invested in the development and popularization of this variety were worked out at ₹ 24.7. Its impact with respect to labour absorption is neutral. Under impact assessment of bio-control of insect-pests and diseases, the mean yield loss estimated due to cultural+ biological+ chemical management practice was minimum at 9.55%, however, the practice was followed by 18.9% farmers. Its impact is positive on labour absorption and it led to increase in labour use per ha. For assessing the impact of intercropping in sugarcane, the average added benefits per ha due to intercropping were found to be quite varied as per the crop selected (₹ 3,750 for pulses, ₹ 4,930 for mustard; potato: ₹ 14,360 and ₹ 67,565 for vegetables. Its impact is positive on labour absorption. The intercropping of vegetables including potato has led to significant increase in labour absorption per ha.

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

The district-level database on sugarcane growth and sustainability in India is the need for the preparation of futuristic (by 2050) sugarcane crop planning in the country. Trends in area, production and productivity of sugarcane at the district-level for the period 2007-08 to 2017-18 were worked out. The distribution of districts according to productivity levels and the extent of sugarcane area were worked out. Suitable or efficient areas or districts growing sugarcane are those areas which have high spread and high crop productivity. Hence, by working out Relative Spread Index (RSI) and Relative Yield Index (RYI), these indices were used to identify efficient sugarcane growing zones for sugarcane in major sugarcane growing states of Uttar Pradesh, Maharashtra, Tamil Nadu and Karnataka. The criteria used for delineation of zones (Table 8.1) was as follows: RSI>100 and RYI>100 for MECZ, RSI<100 and RYI>100 for ECZ, RSI>100 and RYI <100 for LECZ and RSI <100 and RYI <100 for NECZ.

Most efficient sugarcane cropping zone (MECZ) districts constitute around 59 to 69% of the area under sugarcane in four major sugarcane growing states in India (Table 8.1). Specially, these constitute 59.11% of area under sugarcane in Karnataka, 62.47% in Tamil Nadu, 62.90% in Uttar Pradesh and 69.04% in Maharashtra. The yield levels in these districts are quite high at an average level of 83.79 t/ha in Uttar Pradesh, 100.31 t/ha in Karnataka, 106.55 t/ha in Maharashtra and 107.24 t/ha in Tamil Nadu. There are six most efficient sugarcane growing districts in Maharashtra *viz*., Ahmednagar, Solapur, Pune, Sangli, Satara, Kolhapur, while less efficient growing districts are Nandurbar and Latur. There are 27 districts, out of 35 districts which are not efficient for sugarcane cultivation in the state. In Karnataka, out of 30 districts, the most efficient sugarcane growing districts in Karnataka are just three districts *viz*., Belgaon, Mandya and Chamaranagar. In Tamil Nadu, out of 31 districts, only five districts *viz*., Cuddalore, Namakkal, Erode, Tiruvannamalai and Villupuram are the most efficient sugarcane growing districts, while 12 other districts also fall under the efficient category as having yield levels greater than the state level yields. Nine districts in the State come under the not efficient category. In Uttar Pradesh, 13 districts are the most efficient sugarcane growing districts, three districts are efficient ones, seven

Table 8.1. Sugarcane area and productivity in different states

Sugarcane Growing Zone	Abbr.	Share in area under sugarcane (%)	Yield (t/ha)	No of districts	Share in area under sugarcane (%)	Yield level (t/ha)	No. of districts
		Maharashtra			Uttar Pradesh		
Most Efficient Cropping Zone	MECZ	69.04	106.55	6	62.90	83.79	13
Efficient Cropping Zone	ECZ	0	0	0	2.54	81.12	3
Less Efficient Cropping Zone	LECZ	6.08	67.54	2	20.75	72.98	7
Not Efficient Cropping Zone	NECZ	24.88	58.27	27	13.81	67.63	52
State Total		100	92.17	35	100.00	79.25	75
		Tamil Nadu			Karnataka		
Most Efficient Cropping Zone	MECZ	62.47	107.24	5	59.11	100.31	3
Efficient Cropping Zone	ECZ	8.86	102.56	12	3.08	113.88	6
Less Efficient Cropping Zone	LECZ	15.52	78.92	5	3.88	74.10	1
Not Efficient Cropping Zone	NECZ	13.14	87.44	9	33.92	82.46	20
State Total	Total	100.00	99.83	31	100.00	93.65	30

districts are less efficient, while 52 districts are not efficient for sugarcane cultivation. Policy is needed to discourage sugarcane cultivation and encourage other alternative crops in not sugarcane efficient growing districts in these states.

Analysis of uncertainty in farm income in closed sugar mill command area

Based on an analysis of crop cultivation behaviour of 36 smallholder farmers in sugar mill command area of a closed sugar mill for two time periods of 3 years each, period 1 from 2014-15 to 2016-17 and period 2 from 2017-18 to 2019-20, in Vaishali district of Bihar. The smallholders who were following the conventional cropping pattern of sugarcane-rice and rice-wheat earlier when the sugar mill was in operation. After the introduction of agricultural roadmaps in Bihar state, the growers though shifted to commercial cropping (brinjal, tobacco, flowers, vegetables like lady fingers and cucurbits) during period 1 by allocating 42 per cent of GCA to commercial crops under the influence of new policy initiatives, favourable farm and market situations. The main factors responsible for this shift was the need for cash inflows on daily basis, the awareness creation with the opening of more number of fertilizers and pesticides sale-points, and the easy availability of the leased-in land. The change towards commercial cropping resulted in higher profitability and farm income. The farm income was ₹ 4.0 lakh per ha in period 1 and was 5.42 times more than under the conventional farming in period 2. The casual labour absorption during this period was also quite high, 190 days per farm (317 days per ha) and the casual labour use was to the extent of 79.2 per cent of the total labour requirement. The farm prices were lower than the declared MSPs except for the pulses. The same small holders abandoned the commercial cropping to a greater extent in period 2. The main reasons responsible for shifting back to conventional cropping was the poor rain water drainage on account of uplands and contiguous low lands in the village resulting in continuous flooding ranging from a week to a month long period, and the very low prices of commercial vegetable crops during one year. In order to sustain the commercial cropping and higher incomes to small holders in the state, agro-processing units in the area are desired. There is also a need for strengthening of market infrastructure like cold storages, crop based support services and market intelligence. With the development of a biofuel policy in India, the prospects of small ethanol producing units from sugarcane, perishables and crop residues need to be explored in such areas.

Estimation of cost of cultivation of sugarcane in UP

Based on the data compiled from the farmers in central UP by conducting a survey for the sugarcane season 2020-21, the plant crop cost of production was ₹ 3,076/tonne and the ratoon crop cost of production was ₹ 2,891/tonne. Accordingly, the average cost of sugarcane production was worked out at ₹ 2,984/tonne. These estimates were also prepared in the form of note and submitted to UP Sugarcane Department for consideration of State Advised Price Fixation Committee under the Chairmanship of the Chief Secretary, Govt. of Uttar Pradesh.

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

During 1991 to 2020, a large number sugarcane experiments (5265) were conducted in five sugarcane zones with different agro-ecological conditions under Crop Improvement Programme of All India Coordinated Research Project on Sugarcane-AICRP(S). The trials were conducted in Randomized Complete Block Design (RCBD) at nearly 35-40 locations in the sugarcane growing zones of the country. Number of replications were three for nearly 98% of the experiments. The study was undertaken with the objective to know the extent of variability of sucrose (%) in experiments in different

zones. The CV (%) of sucrose departed substantially from normality. A non-parametric method Bootstrap method was used to calculate the upper limit of CV (%), when normality assumption is not required.

Bootstrap bias is negligible for all the crop of sugarcane. As level of significance increases, the upper limit of CV (%) of sucrose decreases. It is inferred that upper limit of CV (%) is more in ratoon crop than the plant crop because the gaps in sugarcane field is more in comparison to plant crop. Gaps occur due to death of clumps (plants) from pests and diseases. It also indicated that upper limit of CV (%) is more in early crop than the mid-late. It may be due to the plot size of experiment. Plot size of mid-late trials are more than the early trials in sugarcane crop. Upper fiducial limit of CV (%) for sucrose (%) of plant crop at 1%, 5% and 10% is around 3.6% of CV for all the three level of significance. Similarly for ratoon crop, it is around 3.5 at all the three level of significance. In case of overall experiments, Upper fiducial limit of CV (%) for sucrose (%) in sugarcane was estimated around 3.5 to 3.7 at 1%, 5% and 10% level of significance respectively for both early and mid-late crop. Upper limit of CV(%) for early crop and mid-late crop in Peninsular Zone is 4.7 and 4.48 at 5% level of significance. In case of East Coast Zone, upper limit of CV(%) of sucrose for early crop and mid-late crop is 3.73 and 3.33 at 5% level of significance. In case of North West Zone, upper limit of CV (%) of sucrose for early crop and mid-late crop is 2.88 and 2.95 at 5% level of significance. In case of North Central Zone, upper limit of CV (%) of sucrose for early crop and mid-late crop is 3.78 and 3.59 at 5% level of significance. These limits of CV (%) are for sucrose (%) to get the consistent and reliable results in varietal trials conducted in complete randomized block design under All India Coordinated Research Project on Sugarcane in both tropical and sub-tropical India. It is a good measure of the reliability of the experiment, which is, the smaller the CV values of CV, the higher is the reliability of experiment.

Efficiency of designs in sugarcane field experiments

For ratoon crop, the data of twelve characters, number of tillers at 90, 180 and 210 days, Brix and sucrose (%) at 10 month, height, girth brix (%), sucrose, internode, NMC and weight at harvest were recorded for both Alpha Lattice Design (ALD) and Randomized Complete Block Design (RCBD). The data of each parameters were subject to statistical analysis according to the technique of analysis of variance (ANOVA) for the ALD. The data of twelve characters were analyzed in ALD and RCBD using SAS 9.3 software. The coefficient of variation (%), 'error mean square' and 'standard error' of the difference between two means and 'efficiency of designs' for different characters for two design were calculated. The significance of different characters in different designs were also tested and estimated at 5% level.

For ALD, out of twelve characters, number of tiller at 90, 180 and 210 days, brix and sucrose (%) at 10 month, height, girth brix (%), sucrose, internode, NMC and weight at harvest were significant at 5% level of significance. Similar results were also found for RCBD arranged using ALD. 'Error mean square' of most of the biometrical characters were estimated less for ALD in comparison to RCBD arranged using ALD. For cane yield, ALD (2191) had less than RCBD arranged using ALD (2207). Similarly, RCBD had Error mean square more than ALD estimated at 3393.

Coefficient of variation (%) for number of tillers at 90 and,180 days, Brix and sucrose (%) at 10 month, height, and weight at harvest were recorded. Height and girth at harvest were found less for ALD in comparison to RCBD. Similar results were observed for RCBD arranged using ALD except for a few characters. The ALD had more value of alpha than other two designs. The ALD was found superior than RCBD arranged using ALD for tiller (90 days) (23.18%), tiller (180 days) (27.36), tiller (210 days) (0.23%), sucrose (%) at 10 month (2%), height (15.74%), girth (3.86%), internode (18.37%) and weight at harvest (2.74 %). Similarly efficiency of ALD was found superior than RCBD for number of tiller at 90, 180 and 210 days, height, girth, NMC and weight at harvest. Hence, the ALD was more efficient than RCBD conducted separately with same number of varieties for most of the important biometrical characters for sugarcane ratoon. Similar results were also observed for sugarcane plant crop.

Internet of things and artificial intelligence enablers in sugarcane farming system

Project has been initiated to explore the priority/ possible/potential area of incorporating IoT and AI based systems in sugarcane; and to explore the IoT and AI enablers to improve efficiency of sugarcane farming. Initiated literature review about IoT applications in agriculture using online tools *viz*. J Gate Search Engine and Microsoft Academics. Searches come out with 3,383 results about IoT applications in agriculture. Data processing operations such as pooling, duplicate removal and filtering operations were performed in many stages on data received. Information about scientific ratings of publications was added. On filtering these results, we found 654 research articles on this aspect, out of which 285 articles were found to be in rated journals. Initial studies indicated that although sensor technologies are quite old but the real boost of IoT applications in agriculture domain came from 2017-18 onwards. A trend of IoT applications in agriculture is shown in Fig. 8.4.

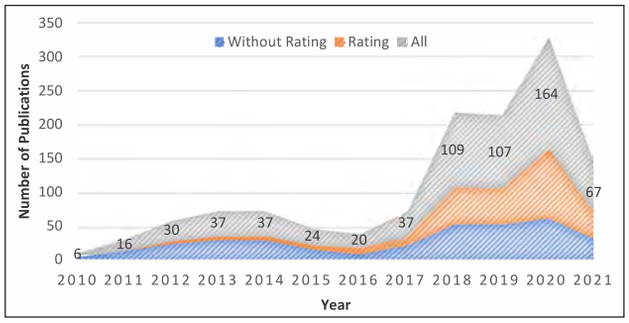


Fig. 8.4. Trends of IoT application

Deep learning application is a class of machine learning algorithms that extract higher-level features from the raw input for making intelligent decisions. Inspired by deep learning abilities and concerns of varietal trials, we have used this technique to identify promising genotypes in sugarcane varietal trials. To construct, train and test deep learning model, datasets of coordinated trials of crop improvement programme for the duration 2016-21 have been used. Model uses crop characters *viz*. cane yield, sucrose%, CCS%, and CCS yield along with score of monitoring and red rot screening. Deep learning in this study consists of input layer, two hidden layers and output layer. Output classes are 'Promising" and "Non-promising" in binary form corresponding to promising genotype or otherwise. Model performed quite accurately with dataset undertaken for identification of promising genotypes.

Web based reporting system for the trials of AICRP on Sugarcane

Generated profiles and excel files for recording of data of zonal varietal trials and crop production trials for the year 2020-21. Experiment profiles and excel files were generated for 46 initial varietal trials under early and mid-late categories. 56 experiment profiles and excel files were generated for advance varietal trial (plant crop 1) under early and mid-late categories. Similarly, 61 such profiles and excel files were created each for advance varietal trial (plant crop 2) and advance varietal trial (ratoon crop) under early and mid-late categories. For crop production trials, a total of 52 such profiles and excel files were generated using AICRP Reporter software consisting of experiments *viz*. Agronomic performance of elite sugarcane genotypes, the evaluation of sugarcane varieties for drought tolerance and the precision nutrient management through rescheduling time of application for widely spaced sugarcane plant-ratoon system. Further, added and updated modules for reporting and analysis of data for zonal varietal trials and crop production trials.

CHAPTER 9

All India Coordinated Research Project on Sugarcane

Salient achievements

To develop location specific high yielding sugarcane varieties with high sugar, zonal varietal trials of early and mid-late maturing varieties were conducted to screen the promising genotypes. In view of developing abiotic stress tolerant varieties, ISH & IGH programmes are being executed at certain centres for both drought as well as water-logging conditions. For varietal development, the year 2021 has been important as twelve sugarcane varieties have been developed (5 identified and 7 released & notified) for different zones of the country. A brief description of developed varieties is mentioned as below:

A. Sugarcane varieties identified

1. **Co 14012 (Avani):** This variety has been developed by ICAR-SBI, Coimbatore in mid-late group for Peninsular Zone and identified in 2021. The variety has exhibited cane yield by 109.82 t/ha, CCS yield 16.16 t/ha and sucrose 20.63% in juice. The variety showed resistance to smut and YLD. It is a non-flowering clone and good ratooner.

2. **CoLk 15201 (Ikshu-11):** This sugarcane variety has been developed by ICAR-IISR, Lucknow in early group for North West Zone and identified in 2021. The variety has exhibited cane yield by 93.92 t/ha, CCS yield 11.44 t/ha and sucrose 17.64% in juice. Reaction against red rot was moderately resistant, moderately susceptible through plug method &

resistant through cotton swab method. The clone showed less susceptible reaction for major insect-pests.

3. **CoLk 15207 (Ikshu-12):** This sugarcane variety has been developed by ICAR-IISR, Lucknow in mid-late group for North West Zone and identified in 2021. The variety has exhibited cane yield by 84.53 t/ha, CCS yield 10.97 t/ha and sucrose 18.71% in juice. Reaction against red rot was moderately resistant through plug method and resistant to cotton swab method. The clone showed less susceptible in reaction of major insect-pests.

4. **CoLk 15466 (Ikshu-13):** This variety has been developed by ICAR-IISR, Lucknow in early group for North Central & North East Zones and identified in 2021. The variety has exhibited cane yield by 85.97 t/ha, CCS yield 10.41 t/ha and sucrose 17.54% in juice. Reaction against red rot was moderately resistant through plug method and resistant through cotton swab method. The clone showed less susceptible in reaction of major insect-pests.

5. **CoP 11438:** This variety has been developed by SRI, Pusa under Dr Rajendra Prasad Central Agricultural University, Pusa, Distt. Samastipur (Bihar) in early group for North Central & North East Zones and identified in 2021. The variety has exhibited cane yield by 78.20 t/ha, CCS yield 9.46 t/ha and sucrose 17.37 % in juice. Reaction against red rot was moderately resistant & moderately susceptible through plug method and resistant through cotton swab method. The clone showed less susceptible in reaction of major insect-pests.

B. Sugarcane varieties released and notified

1. **VSI 12121:** This variety has been developed by VSI, Pune (Maharashtra) in mid-late group and released in 2021 for Peninsular Zone. The variety has exhibited cane yield (124.70 t/ha), sucrose (%) in juice (20.07) & CCS (18.22 t/ha). This variety is suitable for planting autumn and spring seasons. This variety is tolerant to drought and salinity stresses.

2. **Co 13013 (*Akshaya*):** This variety has been submitted by ICAR-SBI, Coimbatore (Tamil Nadu) and released in 2021 for Peninsular Zone. It is a mid-late maturing clone having cane yield (121.96 t/ha), sucrose (%) in juice (19.01) & CCS (14.75 t/ha). Reaction against red rot was moderately resistant (MR).

3. **MS 13081 (*Phule* 10001):** This variety has been developed by the CSRS, Padegaon (Maharashtra) and released in 2021 for Peninsular Zone. It is an early maturing clone having cane yield (118.51 t/ha), sucrose (%) in juice (19.78) and CCS (16.84 t/ha). Reaction against red rot was moderately resistant (MR).

4. **Co 15023 (*Karan*-15):** This variety has been developed by ICAR-SBI Regional Centre, Karnal (Haryana). It is an early maturing clone and released in 2021 for North West Zone. The variety recorded cane yield (89.17 t/ha), sucrose (%) in juice (19.41) and CCS (12.16 t/ha). Reaction against red rot was moderately resistant (MR).

5. **CoLk 14204 (*Ikshu*-8):** This variety has been developed by ICAR-IISR, Lucknow in mid-late group and released in 2021 for North West Zone. The variety recorded cane yield (92.73 t/ha), CCS (11.39 t/ha) and sucrose % in juice (17.73). The clone showed disease reaction of moderately resistant (MR) to red rot.

6. **CoPb 14185 (CoPb 98):** This variety has been developed by PAU RS, Faridkot in mid-late group and released in 2021 for North West Zone. The variety has exhibited cane yield (88.99 t/ha), sucrose (%) in juice (18.50) and CCS (11.58 t/ha). Reaction against red rot was moderately resistant (MR).

7. **CoP 09437 (*Rajendra Ganna* 2):** This variety has been developed by SRI, Pusa in mid-late group and released in 2021 for North Central & North Eastern Zones. The variety has exhibited cane yield by 77.68 t/ha, CCS yield 9.41t/ha and sucrose 17.60% in juice. It is moderately resistant to red rot, smut and wilt diseases. It is tolerant to water logging as well as drought condition

Events/Meetings/Trainings Organized

Zonal Breeders & Plant Pathologists Meet of AICRP on Sugarcane

Zonal Breeders and Pathologists Meet of All India Co-ordinated Research Project on Sugarcane was organized under the Chairmanship of Dr. T.R. Sharma, Deputy Director General (Crop Science), ICAR in virtual mode on January 25, 2021. Sugarcane breeders and pathologists from East Coast Zone, North West Zone and North Central and North East Zones participated in the meeting. In the meeting, performance of the entries in comparison to the best standard in IVT is assessed for field stand, sucrose content at 8th and 10th months for early entries and 10th month for mid-late entries and reaction to red rot and smut. The report on the performance of entries submitted by the monitoring teams of the respective zones was also considered for selecting the promising entries for evaluation in AVT next year.

Recommendations and Action Points

- The yield level of experimental trial should be higher than the cane yield of respective state for consideration of data for advancing the genotype at next stage.
- In few experiments, it has been observed that the performance of ratoon crop was poor. Thus, it becomes inevitable to reject the data of the experiment. Hence, proper management of experiments is required for raising the yield level.
- The information/data of survey done by the scientists of AICRP centres on invitation of sugar mill should be recorded as per set standards for inclusion in the AICRP (S) report, besides reporting to the mills.
- In view of sustaining the popular variety like Co 0238, cultivation of this variety in North-West sugarcane growing zone in red rot free pockets may be continued. However, the cultivation of Co 0238 in *tarai* region may be restricted in view of larger area infested through red rot disease.
- In view of climate change, the build-up of new diseases and pests need to be addressed.
- Survey and surveillance of various diseases and insect pests of sugarcane by both pathologists and entomologists are to be taken up regularly, following standard protocols.
- Sugarcane varieties suitable to ethanol production and strategies of using whole sugarcane as raw material for direct ethanol production needs to be explored for cost reduction.

Annual Group Meeting of AICRP on Sugarcane

The Annual Group Meeting of AICRP on Sugarcane was organized through hybrid mode (physical and virtual) at ICAR-IISR, Lucknow during October 21-22, 2021 with an objective of reviewing the research progress and framing the Technical Programme for 2022. The Meet was inaugurated by the Chief Guest, Dr. T.R. Sharma, Dy. Director General (Crop Sciences). Among other dignitaries, Dr. S. Solomon, Ex-VC, CSAUA&T, Kanpur; Dr. R.K. Singh, ADG (CC), ICAR; Dr. D.K. Yadav, ADG (Seeds), ICAR; Dr. A.D. Pathak, Director and Project Coordinator, ICAR-IISR, Lucknow; Dr. G. Hemaprabha, Director, ICAR-SBI, Coimbatore and Members of Programme Advisory and Monitoring Committee gave valuable suggestions and input. Scientists and associated staff with AICRP on Sugarcane working at the different centres participated in the meeting. Dr. A.D. Pathak, Director and PC (S) welcomed and presented the salient achievements of AICRP on Sugarcane.

Dr. T.R. Sharma, Deputy Director General (Crop Science), ICAR in his inaugural address complemented for completing more than fifty years of AICRP on Sugarcane and development of 136 improved sugarcane varieties through its core varietal development programme. He emphasised upon following points for future course of action:

- Development of water efficient sugarcane varieties, requiring less number of irrigation and withstand water deficit conditions and specific irrigation technology particularly the drip irrigation to replace the flood irrigation.
- Unprecedented spread of a single variety over a large area should be avoided in order to maintain proper balance of diversity in germplasm to save from possible biotic stresses which happened with cultivar Co 0238.
- Pre-breeding is necessary because homozygosity is creating a problem of susceptibility against viruses.
- Identification of specific genes responsible for susceptibility to sugarcane and gene editing through genome editing approaches by

biotechnologists and plant biologists is the need of the day. It would be useful for retaining the genetic background of Co 0238 along with creating resistance to red rot should find a place in our research priority.

- Strengthen the crossing block of Coimbatore by hybridization and distribute to multi-location centres for testing.
- A workshop on 'Development of product profile'' involving all the breeders, pathologists, entomologists and agronomists for all targeted traits of sugarcane should be organized.
- Keep track on the invasive pests/pathogens noticed at few locations by the scientists, in order to keep them under control and more focus is required on use of bio-fertilizers and bio-control measures in sugarcane.
- Doubling of farmer's income through suitable intercrops with sugarcane is encouraged. Emphasis is required on reducing cost of cultivation by various means to reduce the cost of product to compete at global level.

Varietal Identification Committee Meeting

Varietal Identification Meeting was held under the chairmanship of Dr. T.R. Sharma, Deputy Director General (CS), ICAR, New Delhi on October 21, 2021 through hybrid Mode. Five sugarcane clones *viz*., Co 14012 (*Avani*), CoLk 15201 (*Ikshu*-11), CoLk 15207 (*Ikshu*-12), CoLk 15466 (*Ikshu*-13) and CoP 11438 were identified in the meeting for release.

CHAPTER 10

Outreach Programmes and Technology Management

Entrepreneurship development for sugarcane seed production and multiplication

Entrepreneurship is not the function of support systems or external factors alone. Equally important is the individual who responds to the external opportunities. Entrepreneurship is not only inborn, hereditary, confined to few classes or sex, but it can be developed as well. If sincere efforts are made, the latent or potential entrepreneurship might be brought out. The concerted effort was applied under the project to develop entrepreneurial ability of cane growers in healthy seed cane production and marketing. A successful agri-entrepreneurial venture opens the opportunity for entrepreneur to earn profit and at the same time, it provides a social outfit for creation of employment to youths and dwellers in rural settings. With these objectives, entrepreneurship development activities were implemented during the year, mainly focusing to solve the problems like unavailability of healthy seed materials of new cane varieties; lack of entrepreneurial ability among farmers to venture out in seed cane production enterprise and lack of technical know-how in seed cane production and multiplication among farmers.

Production and multiplication of healthy seed material

- Seed cane crop of varieties *viz*., CoLk 94184, CoLk 09204, CoLk 11206, CoLk 11203, CoLk 14201, CoLk 12207, CoLk 12209, Co98014, Co 0118, Co 08272, Co08279, CoS 13235 and Co15023 was planted on farmers' fields in Sitapur, Lakhimpur Kheri, Farrukhabad, Ballia, Pilibhit, Ayodhya and Hardoi districts of Uttar Pradesh and Samastipur and Begusarai districts of Bihar. A total of 114 seed cane plots in 46 ha area was maintained in fields of more than 50 farmers (Table 10.1 and Fig. 10.1).
- The average yield obtained for seed cane crops of different varieties shown in 2020-2021 and harvested in 2021-2022 were 110, 118, 106, 110, 105, 110, 116, 108, 116, 118, 98, and 102 t/ha for varieties CoLk 94184, CoLk 14201, CoLk 11203, CoLk 09204, CoLk 11206, Co 08272, Co 98014, CoS 13235, Co 15023, Co 0118, Co 08279 and CoS 09232, respectively (Table 10.2 and Fig. 10.2). However, the average seed cane yield for all the varieties was 109.75 t/ha. A total of 2758.60 tonne seed cane was produced out of which 71.02% (1959.20 t) was utilized as seed material through sale to other farmers or on own farm to raise seed cane crop in order to multiply the quantity of seed cane of new varieties and rest of the harvested cane *i.e.* 799.4 t (28.98%) was supplied by farmers to sugar mill/jaggery unit for crushing (Table 10.2).
- The overall average net profit and B:C ratio recorded for seed cane crops was ₹ 3,22,323 per ha and 2.48, respectively. The average net profit of ₹ 1,63,000 per ha and B:C ratio of 1.48 was recorded under conventional method in the study areas. The maximum net profit of ₹ 3,86,250/ha was obtained for variety CoLk 14201 and minimum was obtained for CoS 08279 *i.e.* ₹ 2,41,450/ha (Table 10.2 and Fig. 10.3).

Table 10.1. No. of plots and area under seed cane crop of each variety (2021-2022)

S. No.	Variety	Area (ha)	No. of seed plots
1	CoLk 94184	5	10
2	CoLk 14201	8	25
3	CoLk 11203	4	10
4	CoLk 12207	1	4
5	CoLk 09204	1	4
6	CoLk 11206	2	4
7	CoLk 12209	2	6
8	Co 08272	3	6
9	Co 98014	3	6
10	CoS 13235	4	10
11	Co 15023	4	10
12	Co 0118	7	15
13	Co 08279	2	4
	Total	46	114
	Total number of farmers	**50**	

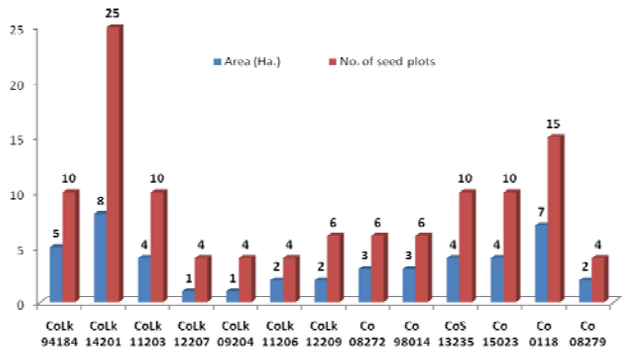


Fig. 10.1. Number of plots and area under seed cane crop of each variety (2021-22)

Table 10.2. Seed cane yield, seed cane production & utilization, economics of seed cane crop (planted in 2020-2021 and harvested in 2021-2022)

Variety	Average yield (t/ha)	Total seed cane produced (t)	Seed cane utilization pattern (in t)		Gross return (₹/ha)			Net profit (₹/ha)
			For seed multiplication	Crushing	Seed @ ₹ 4,375/ ₹ 4,250 per t	Crushing @ ₹ 3,500 & ₹ 3,400/t	Total	
CoLk 94184	110	550	400 (72.73)	150 (27.27)	350000	105000	455000	325000
CoLk 14201	**118**	**177**	**177 (100.0)**	**0 (0.0)**	**516250 3068000***	**0**	**516250 3068000***	**386250 2918000**
CoLk 11203	106	106	80 (75.47)	26 (24.53)	350000	91000	441000	311000
CoLk 09204	110	220	100 (45.45)	120 (54.55)	212500	204000	416500	286500
CoLk 11206	105	63	35 (55.56)	28 (44.44)	247945	158644	406589	276589
Co 08272	110	330	250 (75.76)	80(24.24)	364438	93450	457888	327888
Co 98014	116	232	140 (60.34)	92 (39.66)	306250	161000	467250	337250
CoS 13235	108	54	54 (100.0)	0 (0.0)	472500	0	472500	342500
Co 15023	116	23.2	23.2 (100.0)	0 (0)	507500	0	507500	377500
Co 0118	118	885	650 (73.45)	235(26.55)	379181	109615	488836	358836
Co 08279	98	98	45 (45.92)	53 (54.08)	191250	180200	371450	241450
CoS 09232	102	20.4	05 (24.51)	15.4 (75.49)	109375	269500	378875	248875
All varieties	109.75	2758.6	1959.20 (71.02%)	799.4 (28.98%)	340988	111335	452323	322323
Conven-tional	78.00	0	0	78 (100%)	0	273000	273000	163000
Percentage increase in net profit of the farmers								**97.74**

*Production cost @ ₹ 1,30,000/ha (for seed cane crop) and ₹ 1,10,000/ha (for conventional method)
Seed rate: early- ₹ 4375/t, mid-late- ₹ 4250/t
Cane rate (crushing): Early- ₹ 3,500/t, Mid-late- ₹ 3,400/t

*Sold @ ₹ 2 per single bud sett, 13,000 single bud setts per tonne & production cost is ₹ 1.5 lakh per ha.

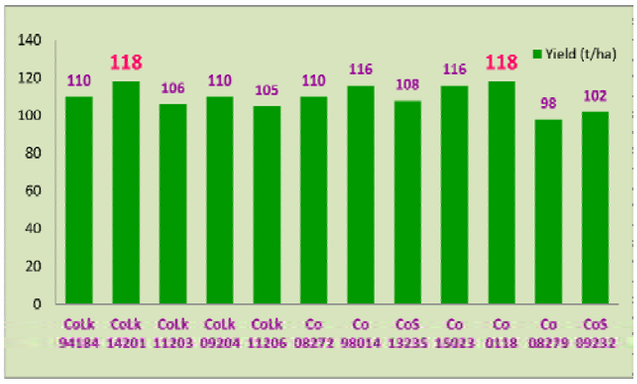


Fig. 10.2. Yield of different cane varieties (t/ha)

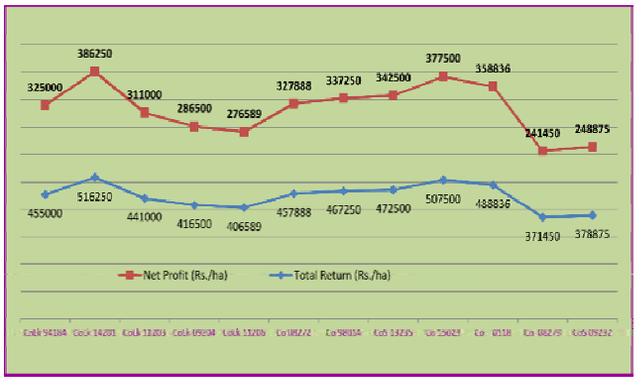


Fig. 10.3. Variety-wise return and profit (₹/ha)

- The maximum yield and utilization for seed purpose was recorded for the varieties like CoLk 14201, Co 15023, CoS 13235, Co 0118 and CoLk 11203. These varieties are gaining popularity among farmers and hold good promise in future for replacement of Co 0238, which is now slipping out of farmers' favour due to heavy pest and disease infestation.
- Farmers who raised seed cane crops, earned 97.74 per cent more profit over conventional method. The target of doubling farmers income can easily be achieved by introducing the intervention like entrepreneurship in seed cane production in cane growing areas.
- Exceptionally high net profit of ₹ 29.18 lakh per ha was earned by farmers through sale of healthy seed cane of CoLK 14201 @ ₹ 2 per single beed sett (Table 10.2).

Entrepreneurship development

- The entrepreneurship training for beneficiary farmers was organised in the months of January, February, March, September, October, November and December to provide information in seed cane crop raising, new cane varieties, motivate the farmers for enterprising in cane seed production and multiplication of new sugarcane varieties.

- Farmers' visit to model farm on seed crop and integrated farming was organised for experiential learning of farmers in true spirit of "*seeing is believing*". Seed cane producer club was formed in the villages and a meet was organised for motivating them for seed cane business.
- The data on entrepreneurial ability of farmers (50) was collected with the help of interview schedule comprising 10 parameters/traits of entrepreneurial behaviour (EB) *viz*., risk taking, innovativeness, hope of success, persuasability, manageability, self confidence, knowledgeability, persistence, use of feedback, achievement motivation. The collected data was compiled and analysed and Entrepreneurial behaviour index (EBI) are presented in Table 10.3 and Fig. 10.4.
- Table 10.3 reveals that overall EBI was increased by 34.73%, however, the maximum increase of 62.4% was recorded in Achievement Motivation attribute of Entrepreneurial Behaviour. However, considerable increases in all the attributes of EB was recorded, which was helpful in enhancing entrepreneurial spirit among farmers. The remarkable increase in Achievement Motivation had greatly contributed in inculcating entrepreneurial quality among farmers. Overall, the positive outcome clearly depicts the success of interventions introduced in the project area.

Table 10.3. Entrepreneurial behaviour index of farmers (n=50)

S. No.	Attributes	Entrepreneurial behaviour index (%)		% Increase	Rank
		Pre	Post		
1	Risk taking	52.8	72.4	37.12	II
2	Hope of success	54.6	68.6	25.64	X
3	Persuability	51.5	69.7	35.34	III
4	Manageability	56.25	73.2	30.13	VIII
5	Self confidence	53.2	71.4	34.21	V
6	Knowledgeability	58.25	76.5	31.33	VII
7	Persistency	52.5	66.8	27.24	IX
8	Feedback Usage	53.5	70.7	32.15	VI
9	Innovativeness	52	70.2	35	IV
10	**Achievement motivation**	**48.4**	**78.6**	**62.4**	I
Entrepreneurial Behaviour Index		**53.3**	**71.81**	**34.73**	

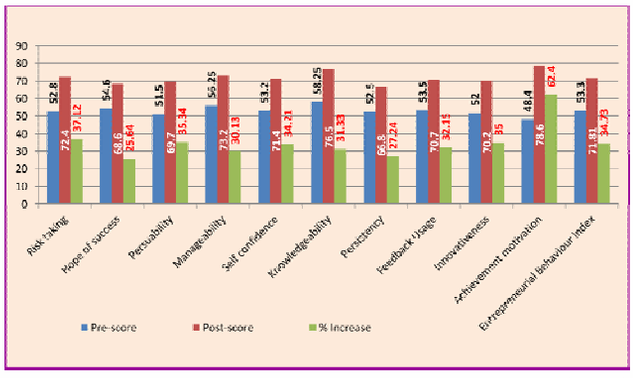


Fig. 10.4. Entrepreneurial behaviour index of farmers (n=50)

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

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, Public-Private-Farmer Partnership (PPFP) model was developed and implemented under outreach programme of the Extension and Training Unit. 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 5,000 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.

Collaborative programme on "Doubling Farmers' Income"

As per an Addendum to the Memorandum of Understanding (MoU) between ICAR-IISR, Lucknow and DCM Shriram Limited, New Delhi signed on 27th September, 2019 in New Delhi, the collaborative programme on "Doubling Farmers' Income" was initiated in 20 villages; 5 villages in each of 4 sugar mills (Azbapur, Loni, Rupapur and Hariyawan) of DCM Shriram Group. The Original MoU was signed in August 2017 to implement the project in 8 villages: 2 villages in each of 4 sugar mills. The successful output achieved in first two years has given impetus to extend the project in 20 villages.

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

Selected villages in each of the 4 sugar mills:

- DSCL Sugar- Ajbapur, District- Lakhimpur Kheri
  - Ajbapur, Mahmoodpur Bhagat, Jasmadi, Mastipur, Jalalpur Gopi
- DSCL Sugar-Rupapur, District- Hardoi
  - Munder, Kanhari, Amirta, Timirpur, Rawatpur
- DSCL Sugar-Hariawan, District- Hardoi
  - Hariawan, Ahmdi, Kayampur, Jiyo, Kuiyan
- DSCL Sugar- Loni, District- Hardoi
  - Loni, Nagla Bhagwan, Dharmapur, Nagla kallu, Rebha Muradpur

Additional income from sugarcane

Due to introduction of cane-based interventions in the eight selected villages (as per Original MoU), the average yield of cane increased from 548 q/ha to 710 qt/ha and net income of farmers from cane cultivation increased by 1.9 times (from ₹ 70,000 per ha in the year 2016-17 to ₹ 1,32,000 per ha in the year 2020-2021).

All the interventions related to sugarcane introduced in all the eight villages gave impressive dividend in terms of increased cane yield and enhanced profit from sugarcane cultivation. This has resulted into an increase of 88.57 per cent in net profit earned by virtue of cultivating sugarcane with component cane technology. A total of ₹ 66.34 million additional annual income was also earned by farmers in the selected villages.

Increase in income of farmers

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

Particulars	2016-2017	2020-2021	Net increase	% increase
Sugarcane yield (q/ha)	548	710	162	29.56
Net profit from sugarcane (₹/ha)	70,000	1,32,000	62,000	88.57
Total annual income from sugarcane in 1070 ha area (million ₹)	74.90	141.24	66.34	88.57

With this kind of increase in income, a total of ₹ 130.11, ₹ 76.78 and ₹ 22.40 million additional net income was earned by 2,300 marginal, 1,578 small and 258 large farmers, respectively, dwelling in the project areas. Thus, a total of ₹ 229.29 million additional income was accrued to the 4,136 farm families in a year (Table 10.4).

Collaborative pilot project on drone

To introduce innovations in farmers' fields, the idea of using drone on pilot basis for application/spraying of different agro-chemicals in sugarcane crop was conceived. For this, thorough discussion with partners in Drone pilot project *i.e.* DCM Shriram Ltd. New Delhi; Mahindra & Mahindra; and General Aeronautics Pvt. Ltd., Bengaluru was held and a proposal was prepared and submitted to Director General, Civil Aviation, Govt. of India for getting permission to use drone on pilot basis. The proposal was accepted and approved by DGCA in March 2021. After approval, thorough discussion with officials of DCM Shriram, Mahindra & Mahindra and General Aeronautics Pvt. Ltd., was held in the months of May and June 2021 and plan of action was decided for use of Drone for spraying of agro-chemicals in standing crop of sugarcane with all provisional precautionary measures. Four agro-chemicals *i.e.*, sprayit (NPK mixture in ratio of 10:30:20), Imidacloprid Shriram Saathi+ urea and Hexastop was applied in cane fields with the help of drone on 3-4 July, 2021 in two villages (Anjhi Adampur and Kathawan) and factory farm in Loni in Hardoi district of Uttar Pradesh (Table 10.5).

Field observations was recorded after 5, 10 and 15 days after spray. Yield and recovery data will be sourced from record of cane supply and crushing in the mill.

Table 10.4. Additional annual income by different category of farmers

Farmers' category	Annual income (₹)		Net increase in annual income (₹)	No. of farmers	Additional total annual income earned (million ₹)
	2016-2017	2020-2021			
Marginal (< 01 ha)	53,432	1,10,000	56,568 (105.87%)	2,300	130.11
Small (01-02 ha)	76,346	1,25,000	48,654 (63.73%)	1,578	76.78
Large (> 02 ha)	1,73,168	2,60,000	86,832 (50.14%)	258	22.40

Table 10.5. Details of agro-chemicals applied in cane fields with the help of drone

Agri-chemicals	Area (ha)		Number of plots		Targeted observations	Cane varieties
	Treatment	Control	Treatment	Control		
Sprayit	0.432	1.90	12	06	Tillers count, cane yield and sugar recovery	Co 0238, Co 0118, CoS 95422
Imidacloprid	1.6	0.8	03	03	Brown & red spots on the leaves, check for pest presence at basal part of the plant.	
Shriram Saathi + Urea	3.15	0.5	08	02	Nutrient deficiency symptoms-Yellowing, chlorotic spots, leaf colour changes, poor tillering	
Hexastop	0.6	0.5	02	02	Leaf burning, necrosis, chlorosis or stunting	

An analysis of gender perspective in sugarcane cultivation

Development of operational difficulty index of sugarcane production technologies (ODISPT)

Operational difficulty of sugarcane production technologies is considered to be composite of six sub-sections (dimensions), *viz.*, 'varieties, planting materials and methods', 'fertilizer & irrigation management', 'weed management/intercultural operation/ intercropping', 'plant protection', 'ratoon management' and 'post-harvest management/ mechanization'. The index was developed by following the given procedure:

I. **Selection of the dimensions:** Authenticated literature and discussion with the experts in relevant field played an important role in the identification of the dimensions. Broadly, these dimensions were grouped into 6 categories.

II. **Determination of scale values:** It has been decided to give specific weights (Scale Values) to each dimension of the ODISPT based on their perceived significance. The 'Normalized Rank Order Method' suggested by Guilford (1954) was used for determining the scale values. As per the method, 6 different dimensions of ODISPT were ranked by the judges according to their perceived significance in determining the status of difficulty. Questionnaire containing dimensions of ODISPT was sent through e-mail and also handed over personally to the total 250 judges for ranking. Only 38 judges returned the filled in questionnaire. Out of 38 responses, three responses were found unsuitable for analysis and eliminated after careful examination. The rankings given by all 35 judges were summarized. In the next step, the proportions were worked out for the ranks assigned by all the judges. The *p* values were worked out for all the ranks. Thus, *p* values for the ranks ranged from the lowest 16.67 to the highest 83.33.

The next step is to find out the C values for all the ranks. The C values were determined for each rank from the Table-M (Guilford 1954). In the case of this experiment, the numbers of dimensions were 6, thus, the number of stimuli to be ranked were 6.

The next step is to find out the "($f_{ji}C$) value for all the dimensions. This value for every dimension was obtained by multiplying the frequencies found in the columns of the respective dimension by the C values of the rank (r_i), and summing up the products for each dimension and entering the same in the row against "($f_{ji}C$). The mean of the total frequencies, that is for the whole data of the matrix was 5.50 (1155/210=5.50) and the mean of the C values was 5.50 (33/6=5.50). Then the "($f_{ji}C$) values for each dimension was divided by the total number of judges 35, which resulted in obtaining the M_c = R_j. The treatment of data can be stopped at this stage and the M_c values can be accepted and treated as the scale values. The scale values for 'varieties, planting materials and methods', 'fertilizer & irrigation management', 'weed management/intercultural operation/inter cropping', 'plant protection', 'ratoon management' and 'post-harvest management/mechanization' were 6.74, 5.40, 5.57, 5.69, 5.06 and 4.54, respectively. The sum of these values was 33 which was also the sum of the C values indicating the accuracy of the calculation. As per the procedure, sum of the scale values and the C values should be same. The mean of the M_c or R_j or R_c values was 5.50. The standard deviation and standard error of the M_c values was 0.74 and 0.12, respectively.

III. **Selection of the indicators of difficulty index:** To measure the operational difficulty, indicators under each dimension were selected after preliminary survey of the study area, consultation of the literature as well as the experts such as scientists, officials of the related departments and personnel from NGOs working in the area.

A. **Collection and editing of indicators:** By referring the available literature on relevant subject,

consulting the researchers, farmers and extension experts, a total of 58 items (indicators) were collected covering the almost entire universe or content. The indicators were edited as per the 14 informal criteria suggested by Edwards (1969) and as an outcome 13 indicators were eliminated. Finally, 45 indicators were retained after editing and considered for judges' rating.

B. Judges rating: Selected indicators were subjected to the judges' rating in three point continuum, *i.e.*, most relevant, relevant and not relevant with respective scores of 3, 2 and 1. These questionnaires were sent to the total 250 judges. Out of 250 judges, 38 judges returned the same set of indicators after duly recording their judgments in a stipulated span of two months. Out of 38 filled in questionnaires, three were found unsuitable for item analysis and eliminated after careful examination of responses.

C. Relevancy test: These indicators were subjected to scrutiny and their subsequent screening for inclusion in the final index. The relevancy weightage (RW) and mean relevancy score (MRS) were worked out for all the indicators individually as well as overall mean relevancy score (OMRS) including all the indicators was calculated by using the following formula:

$$RW = \frac{(\text{Most relevant response} * 3 + \text{Relevant response} * 2 + \text{Not relevant response} * 1)}{\text{Maximum possible score}}$$

$$MRS = \frac{(\text{Most relevant response} * 3 + \text{Relevant response} * 2 + \text{Not relevant response} * 1)}{\text{Number of judges}}$$

$$OMRS = \frac{(\text{Most relevant responses} * 3 + \text{Relevant responses} * 2 + \text{Not relevant responses} * 1)}{\text{Number of judges} \times \text{Number of statements}}$$

Whereas,

RW= Relevancy weightage

MRS= Mean relevancy score and

OMRS=Overall mean relevancy score

By these criteria, the statements having relevancy weightage (RW) *i.e.*, 0.80 and mean relevancy score (MRS) greater than the overall mean relevancy score, *i.e.*, 2.39 were considered for inclusion in Operational Difficulty Index of Sugarcane Production Technologies and finally 30 statements were included.

IV. Construction of the composite Operational Difficulty Index of Sugarcane Production Technologies

The first step is to construct the index (Iij) for each i^{th} indicator representing j^{th} dimension of composite index. For making indicator scale free, following methods was applied:

$$I_{ij} = \frac{Xij - MinXij}{Max\,Xij - MinXij}$$

Whereas, i = 1, 2, 3……..n Indicators

j = 1, 2, 3 dimension of ODISPT

X_{ij} = Value of i^{th} indicator of j^{th} dimension

Having calculated the I_{ij} for all the indicators, the second step is to calculate the indices for various dimensions of composite index. It is calculated as the simple mean of their respective variables, that is:

$$ODIV = \frac{\sum_{i=1}^{n} Iij}{n},\ ODIFI = \frac{\sum_{i=1}^{n} Iij}{n},\ ODIWM = \frac{\sum_{i=1}^{n} Iij}{n},,$$

$$ODIPPT = \frac{\sum_{i=1}^{n} Iij}{n}, ODIRM = \frac{\sum_{i=1}^{n} Iij}{n}, ODIPHT = \frac{\sum_{i=1}^{n} Iij}{n}$$

Whereas,

ODIV = Operational Difficulty Index for Varieties, Planting materials and Methods

ODIFI = Operational Difficulty Index for Fertilizer & Irrigation Management

ODIWM = Operational Difficulty Index for Weed Management/Intercultural Operation/Intercropping

ODIPPT= Operational Difficulty Index for Plant Protection

ODIRM = Operational Difficulty Index for Ratoon Management

ODIPHT = Operational Difficulty Index for Post-harvest Management/Mechanization

Iij= Index for the j^{th} dimension containing n indicator

n= No. of indicators

Then, the composite Operational Difficulty Index of Sugarcane Production Technologies for each respondent was calculated as a weighted mean of the indices obtained for different dimensions in following manner:

$$ODISPT = \frac{W1*ODIV + W2*ODIFI + W3*ODIWM + W4*ODIPPT + W5*ODIRM + W6*ODIPHT}{\text{Sum of the scale values of all dimensions}}$$

Whereas,

W = Scale value (weight) assigned to the respective dimension of composite index.

V. Standardization of Index: The validity of the instrument was assessed by content validity. The content of the index was thoroughly covered with literature scan and expert opinions. The indicators having relevancy score of ≥0.80 were retained. As it indicates that more than 80 per cent of judges rated the statement as relevant which indicates that statement is unambiguous and has discriminating power. This indicated the validity of the index

content. As the scale values of all the dimensions, relevancy weightage and mean relevancy scores for indicators had discriminating values, it seemed reasonable to accept the index as valid measure of the desired dimension.

Further, the data from the 30 farmers (men and women) were collected, tabulated and analyzed. The results are as under:

1. **Profile of farmers:** Results revealed that the majority of the farmers were of middle aged followed by old, studied up to intermediate, having medium family education status, maintaining small families, having joint family system, medium social participation, main occupation was agriculture + dairy, growing paddy, sesame, black gram, sugarcane, wheat, mustard, maize, *chari*, *berseem* and mango, majority of them had low annual income, maintained, small herd size, having medium mass media exposure and high extension contact in majority.
2. **Gender perspective in sugarcane cultivation:** In case of role performance, social and economic roles were mainly performed by the men, however, in case of role pertaining to sugarcane production was performed by the men as well as women in almost equal proportion. Further, the roles like cane survey, *satta*, cane supply, *etc.*, were mainly performed by the male members of the family. In case of control and access to the resources as well as the benefits, the men were in dominating position.
3. **Gender wise role in decision making:** Decisions related to farming, sale, purchase, community function and political matters were mainly taken by the men, while keeping of money was the prerogative of women. Further, education, family functions and housing related decisions were taken by both jointly.

Technology and information utilization pattern among the sugarcane growers

An interview schedule comprising the list of important sugarcane technologies *i.e.* use of high yielding variety, seed treatment, planting methods, intercropping, harvesting and value addition *etc.* are available for the farmers is prepared. WhatsApp group of "sugarcane stakeholders" has also been created and responses is being collected through WhatsApp messages/videos and telephonic and video calls. An inventory of innovative sugarcane technologies transferred among the sugarcane growers during the last 10 years is being prepared with the discussion with experts and from the secondary sources. The development of technology utilization index (TUI) is under process and will be used for data collection. Responses/feedback of farmers and stakeholders collected through WhatsApp, telephonic calls and video messages indicated that more than 70 per cent farmers queries were related to procurement/availability of high yielding sugarcane varieties. However, 30 per cent farmers enquired about the control of insect pest and diseases. WhatsApp video messages were recorded as prominent source of communication.

Technology assessed in farmers fields

A. Intercropping in sugarcane

The intercropping of pulses, oilseeds, vegetables, spices *etc.*, with sugarcane has been established as one of the viable options for increasing farmers' income. Technology package for cultivation of different intercrops with sugarcane has been developed by the research institutions. Intercropping technology was demonstrated in farmers' fields to assess its impact on enhancing system yield under real farming situations. In the year 2021-2022, 13 nos. of intercrops with autumn/spring cane (vegetable pea, potato, tomato, mustard, lentil, chickpea, cabbage, cauliflower, pigeonpea, garlic, frenchbeans, mungbean and banana) was demonstrated in the fields of 30 farmers of Sitapur, Lakhimpur Kheri, Hardoi, Pilibhit, and Bareilly districts of Uttar Pradesh covering a total of 20 ha area.

The highest net profit of ₹ 6,98,000/ha with B:C ratio 3.87 was recorded in case of banana grown as intercrop with sugarcane and the lowest net profit of ₹ 2,68,250/ha with B:C ratio 1.91 was earned by the farmers with chickpea intercropping. The net profit for all intercrops was much higher than the profit recorded with sole cane crop *i.e.* ₹ 1,70,000/ha (Table 10.6). This establishes the intercropping with sugarcane as profitable cropping system in comparison to sole cane crop. In addition to higher profit, the intercrops also provided pulses and vegetables to the farmers for their family consumption and thus help in food and nutritional security for village dwellers. The intermittent income earned by farmers from intercrops also helped them in better management of sugarcane crops and meeting out their emergent household expenditure.

B. Ratoon promoter machine

As many as 25 demonstrations on ratoon promoter machine was conducted to assess its benefit in enhancing yield and profit from ratoon crop. It was assessed in farmers' fields in command area of Biswan Sugar Mill, Biswan, Sitapur (U.P.) and DCM Shriram Sugar Mill, Loni, Hardoi (U.P.) covering 06 villages, 25 cane growers and 12.00 ha area. Under all ratoon plots where ratoon promoter machine was operated cane yield enhanced by 12-15 t/ha, cost saving was up to ₹ 6,000/ha and profit enhanced by ₹ 45,000-55,000/ha.

Table 10.6. Economic analysis of intercrops grown with sugarcane

Cropping system	Yield (t/ha)		Return (₹/ha)		Gross return (₹/ha)	Net profit (₹/ha)
	Cane	Intercrop	Cane	Intercrop		
Sole sugarcane	80	-	280000	-	280000	170000
Intervention – Intercropping in sugarcane						
Sugarcane + Vegetable pea	85	7.1	297500	142000	439500	289500
Sugarcane + Potato	88	28	308000	266000	574000	424000
Sugarcane + Lentil	86	1.8	301000	108000	409000	274000
Sugarcane + Chickpea	86	1.95	301000	107250	408250	268250
Sugarcane + Mustard	86	1.75	301000	108500	409500	269500
Sugarcane + Pigeonpea	87	2.0	304500	120000	424500	289500
Sugarcane + Cabbage	90	20.0	315000	260000	575000	425000
Sugarcane + Cauliflower	90	20.0	315000	240000	555000	405000
Sugarcane + Garlic	88	5.0	308000	210000	518000	368000
Sugarcane + Frenchbeans	92	8.0	322000	200000	522000	372000
Sugarcane + Banana	**88**	**38.0**	**308000**	**570000**	**878000**	**698000**
Sugarcane + Mungbean	80	2.5	280000	180000	460000	325000
Sugarcane + Tomato	104	30	364000	330000	694000	539000

Sale price (₹/q): Sugarcane – 350, Vegetable Pea – 2000, Potato – 950, Lentil – 6000, Chickpea – 5500, Mustard – 6200, Pigeonpea – 6000, Cabbage – 1300, Cauliflower – 1200, Garlic – 4200, Frenchbeans – 2500, Banana – 1500, Mungbean – 7200, Tomato – 1100.

Frontline demonstrations on seed production technology, intercropping of pulses, vegetables and oilseeds *etc.*, with sugarcane and bud chip technology and use of ratoon manager machine

For fast spread of newly released cane varieties, 50 nos. of FLDs on seed cane production technology was conducted in farmers' fields in Sitapur, Lakhimpur Kheri, Hardoi, Farrukhabad, Pilibhit and Bareilly districts of Uttar Pradesh and Samastipur and Begusarai districts of Bihar. To popularize intercropping of pulses, vegetables, oilseeds *etc.*, with sugarcane and economize the use of seed rate, a total of 30 FLDs on intercropping with sugarcane and bud chip technology was conducted on total of 20 ha area in Uttar Pradesh. To popularize the use of Ratoon manager machine for proper management of ratoon crop, a total of 20 FLDs in 10 ha area was conducted in Sitapur and Hardoi districts of Uttar Pradesh.

Frontline demonstrations of IISR tractor operated modified sugarcane cutter planter

IISR tractor operated modified deep furrow sugarcane planter was demonstrated at farmers field of Lakhimpur Kheri, Sitapur, Shahjahanpur, Sultanpur, Seorahi in 5.5 ha area covering 14 farmers. With the help of this planter, two rows of sugarcane are planted in a single pass at a row spacing of 75/90 cm. The performance of the planter was satisfactory for planting of sugarcane (including sett cutting) at farmer's field.

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

Cost of planting operation was ₹ 3,500 per ha using the planter as compared to ₹ 8,500 per ha in conventional method.

Frontline demonstrations of IISR tractor operated two row disc type ratoon management device

The frontline demonstration of IISR ratoon management device was conducted in Hardoi, Sitapur and Lucknow districts. Approximately 4.5 ha area was covered by IISR RMD in 8 farmers fields. Feedback information from the farmers' field yielded the necessity of simplifying the metering and power transmission system of the equipment.

Fig. 10.6. IISR tractor operated two row disc type ratoon management device in field operation

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

IISR tractor operated raised bed seeder-cum-sugarcane planter was operated at farmer's field at Biswa sugar mill area of Sitapur district in 4.5 ha area covering 5 farmers. 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. 10.7. IISR Tractor Operated Deep Furrow Sugarcane Cutter Planter–cum-Multicrop Raised Bed Seeder in field operation in Manpur, Sitapur

Frontline demonstrations of IISR Tractor operated multipurpose interculturing equipment

Equipment was demonstrated at farmers field of Sitapur district. Total of 8.8 ha area was covered covering 11 farmers. Results were in agreement with results obtained during field trials at IISR farm. Cost of operation of furrow opening with developed equipment was ₹ 2,442/ha as against ₹ 2,387/ha in conventional ridger. Though the cost of furrow opening marginally increased in the developed equipment but it opened deep furrows to facilitate furrow method of sugarcane planting. The furrow method of planting is considered as superior planting technique in terms of water saving, reduced

Fig. 10.8. IISR Tractor operated multipurpose interculturing equipment in field operation

Fig. 10.9. IISR multipurpose interculturing equipment during earthing up mode

Fig. 10.10. Demonstrations of Manual Multicrop Planter in villages of Biswan sugar mill area

Fig. 10.11. Operation of manual multicrop planter at IISR farm

lodging of cane and better ratooning. Cost of operation in performing combination of operations during weeding/interculturing and fertilizer application in the conventional system was ₹ 4,328/ha whereas with the developed equipment it was ₹ 1,841/ha. The saving in cost of operation was 57%. The corresponding labour saving was 129 man-h/ha (97%).

Thirty four frontline demonstration on manual multicrop planter was conducted in 14.44 ha area.

Field day organized: 11

1. 3rd July, 2021- Anjhi and Loni villages under DCM Shriram Sugar Mill, Loni, Hardoi.
2. 11th August, 2021- Village Baraula, Lakhimpur Kheri
3. 11th August, 2021- Village Shankarpur, Sitapur
4. 12th October, 2021- Village Kathingra, Kakori, Lucknow
5. 22nd October, 2021- Sarojani Nagar, Lucknow
6. 28th October, 2021- Village Manpur, Biswan, Sitapur
7. 1st November, 2021- Heartfulness Institute, IIM Road, Lucknow
8. 24th November, 2021- Saidapur Devkali, Lakhimpur Kheri
9. 11th & 12th December, 2021- Hasanpur Sugar Mill, Hasanpur (Bihar)

10. 23rd December, 2021- Village Rebha Muradpur, Loni, Hardoi
11. 29th December 2021- Heartfulness Institute, IIM Road, Lucknow.

Transfer of technology

Sharing of package and practices of sugar beet: Package and practices of sugar beet cultivation shared with the following research centres and industries:

- Agriculture Research Station, Basanthpur
- ICAR-CSSRI Regional Research Station, Lucknow
- S. Nijalingappa Sugar Institute, Belgavi (Karnataka)
- ICAR-Indian Grassland & Fodder Research Institute, Jhansi
- Siksha O Anusandhan University, Odisha
- Neoko Industries Private Limited, Bengaluru
- Mr. Yestin Totalgaz, Bengaluru

Dissemination of sugar beet seeds

Sugar beet seed supplied to following Research Centres and Private Industries:

1. Sixteen sugar beet seed germplasm, *viz*., IISR Comp 1, LS 6, LKC 11, LKC 2000, L 33, LKC 2007, LKC 2010, LK 7, LKC 95, LKC 2006, LKS 10, LKC LB, LKC HB and LKC 2020 supplied to ARS, Basanthpur.
2. Three sugar beet seed germplasm, *viz*., IISR Comp 1, LS 6 and LKC 2020 supplied to Neoko Industries Private Limited, Bengaluru.
3. Sixteen sugar beet seed germplasm, *viz*., IISR Comp 1, LS 6, LKC 11, LKC 2000, L 33, LKC 2007, LKC 2010, LK 7, LKC 95, LKC 2006, LKS 10, LKC LB, LKC HB and LKC 2020 supplied to three research centre namely, ICAR-CSSRI Regional Research Station, Lucknow, ICAR-IGFRI, Jhansi and S. Nijalingappa Sugar Institute, Belgavi (Karnataka).
4. Two sugar beet varieties, *viz*., LS 6 and IISR Comp 1 supplied to Mr. Yestin Totalgaz, Bengaluru and Siksha O Anusandhan University, Odisha for research purpose.

Collaborations and Linkages Developed

Inter-Institutional Collaborative Research Projects

Inter-Institutional Collaborative Research Projects on sugar beet has been initiated with the following Institutions:

- ARS, Basanthpur
- ICAR-CSSRI Regional Research Station, Lucknow
- S. Nijalingappa Sugar Institute, Belagavi (Karnataka)
- ICAR-IGFRI, Jhansi
- Siksha O Anusandhan University, Odisha

IISR BCC, Pravaranagar activities

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 moth borersof the sugarcane (early shoot, internode and top shoot borer). The egg parasitoid was reared on its natural insect host (rice mealworm, *Corcyra cephalonica*) in the laboratory and good qualities of green trichocards were prepared. Total 1,000 tricho card strips (20 cards) were distributed to the farmers which cover 20 ha sugarcane area.

Activity 2: Mass multiplication and maintenance of host insect rice mealworm (*Corcyra cephalonica*)

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

Activity 3: Mass multiplication and maintenance of greater wax moth (*Galleria mellonella*)

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

Entrepreneurship in operation and maintenance of sugarcane machine

A programme on entrepreneurship in sugarcane machine was initiated in association with Biswan sugar mill and DCM Shriram Sugar group. Programme was organized to demonstrate operation of sugarcane machines and entrepreneurial tips in maintenance and operation of sugarcane machines at Village Manpur, Biswan, Sitapur and Village Rebha Muradpur, Loni, Hardoi.

Exhibitions organized

Sr. No.	Date	Organizer & Place	Event	No. of Visitors
1.	February 16, 2021	IISR, Lucknow	IISR Foundation Day	300
2	February 20-22, 2021	BUAT, Banda	Regional Farmer Fair	1,000
3.	March 26, 2021	DCM Shriram Sugar Mill, Loni, Hardoi	Farmers' Training	150
4	February 26-28, 2021	Pathardeva, District Deoria (UP)	Zonal Farmers Fair (Sugarcane Production Technologies)	500
5	March 21-22, 2021	KVK, Parsauni (East Champaran)	*Unnat Krishi Mela* (Sugarcane Production Technologies)	1,000
6	September 26, 2021	Agriculture Department, Govt. of UP, Sector 15, Vrindavan Scheme, Lucknow	State Level Farmers; Fair	5,000
7	November 13-16, 2021	IAS, BHU, Varanasi (U.P.)	Agricultural Science Congress	1,000
8	December 16-18, 2021	CARD & IISR, Lucknow	U.P. Agro-Vision Business Meets, Expo & Seminar	6,000

MoAs signed related to jaggery technology

Name of the machine/technology transferred	No. of units	Address of farmers/ entrepreneurs/ manufacturers	Date of technology transferred
M/s Krushna Agrotech	01	Satara, Madhya Pradesh	June 29, 2021
Mrs. Bindu Tyagi	01	Sikarpur, Bulandshahr, Uttar Pradesh	August 27, 2021
M/s Patel Manufacturing Company	01	Upleta-360490, Rajkot, Gujarat	September 15, 2021
Khet Kisan Producer Company Limited	01	Fatehpur, Uttar Pradesh	October 12, 2021

Linkages developed

- Technical collaboration with Mahindra and Mahindra and General Aeronautics Ltd., Bengaluru was established for implementation of a pilot project on drone application in command area of DCM Shriram Sugar Mill, Loni, Hardoi.
- Collaboration with Shukla Bandhu Organic Producer Company Limited, Biswan, Sitapur (U.P.) was developed to establish a "Sugarcane based Model Farm" at Purwa Dasapur, Sitapur for promoting agribusiness among rural youth.
- The blue print of MoU was developed to have linkages with WWF India for implementing collaborative outreach programme in the areas of resource conservation technology in sugarcane and agriculture. A blue print of MoU was also developed for linkage with NamFarmers.com for digitalized ToT.

- ICAR-IISR, Biological Control Centre, Pravaranagar has collaboration with the College of Agriculture, Agri. Biotechnology and Allied Colleges of Loknete, Dr. BalasahebVikhe Patil Pravara Rural Education Society, Loni for the promotion of students training and quality undergraduate/postgraduate research, training and extension in sugarcane.

Entrepreneur farmer developed

- Five farmers were developed as entrepreneur and they are doing seed cane business.

Transfer of technology related to jaggery manufacturing

- Eight IISR 3 pan Jaggery unit were established.
- Fifty moulding frames were sold to entrepreneurs.
- Value added Jaggery technology was transferred to four entrepreneurs.
- Improved Jaggery making technology has been demonstrated to visitors.

Commercialization of technologies

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

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

Name of Technology/ Know-How	Name of Contracting Party	Mode of Partnership**	Date of Licensing	Revenue Earned (₹)
Agricultural Machinery Manufacturers	M/s Krushna Agrotech, Karad, Satara (MS)	MoA	29.06.2021	30,000/-
Deep Furrow Sugarcane Cutter Planter	Pishon Technologies, Coimbatore (TN)	MoA	05.10.2021	10,000/-
IISR, Combo Trap for management of sugarcane insect-pests	SKR Agro-Tech, Maharashtra	MoU	29.12.2021	₹ 2.0 lakh as license fee and royalty @ 5% of gross value of each device sold

National Agricultural Innovation Fund (NAIF) Component-1

Management of IP portfolio and commercialization of technologies: The Institute Logo was submitted to the Patent office, New Delhi for its registration as Trademark. The Trademark under class-07 has been registered and Trademark registration under class-30 is under consideration at IP office (Fig. 10.12). The details of IP granted shown in Table 10.8.

Table 10.8. Details and status of IP application submitted for registration of trademark

IPRs	Application/ Registration No.	Specification	Date of filing/ Registration	Application granted/ Registered**
Trademarks	4876604	Under Class-07	23/02/2021	Registered
	4877880	Under Class-30	24/02/2021	Under Process


Government of India
Trade Marks Registry
Trade Marks Act, 1999
Certificate of Registration of Trade Mark, Section 23 (2), Rule 36 (1)
Trade Mark No. 4876604
Dated: 23/02/2021
In Class 7
Under No. 4876604
as on the date 23 February 2021
Machines and machine tools, agriculture implements other than hand operated
Trade Mark as annexed
Sealed at my direction, this 03rd day of August, 2021
Trade Marks Registry MUMBAI
Registrar of Trademarks
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Fig. 10.12. Certificate of registration of Institute logo as trademark

Ikshu Kedar Mobile App

Adequate and timely irrigation, along with other measures, is mandatory to take maximum yield of sugarcane. However, farmers used to apply frequent and excessive irrigation in sugarcane fields to get maximum yield. This results in loss of both water and irrigation expenses. Adoption of water saving technologies is essential to protect our environment and to promote other economic activities. In this respect a Mobile App for irrigation scheduling in sugarcane farming has been developed that enables to predict next date of irrigation based on date of planting and last irrigation. It will be beneficial for high sugarcane yield along with water saving in North Indian conditions. App asks for date of planting and date of last irrigation to suggest next irrigation date. It also gives advisory for irrigation date compliance in sugarcane farming. It has been developed in Hindi language and is available on Google Play store as well as ICAR Krishi portal for download.

CHAPTER 11

Krishi Vigyan Kendra, Lucknow

A. On-farm trials (OFTs): Ten 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 in specific agro climatic condition is done for future recommendations or popularization which are given below:

- **Integrated nutrient management in potato:** Potato is an important commercial crop of Lucknow district. Farmers use fertilizers injudiciously, due to which cost of cultivation was high with poor quality of tubers. So keeping these facts in view, KVK, ICAR-IISR, Lucknow conducted an on-farm trial to assess effect of nutrients' application on the basis of soil test in potato. Nutrients application on the soil test base *i.e.*, 150 kg N + 80 kg P + 100 kg K/ha + 5.62 kg Zn/ha with green manuring of *Sesbania* increased 8.0 per cent tuber yield as compared to farmers practice *i.e.* 250:172:180 kg/ha NPK without soil test. The B: C ratio in soil test base *i.e.*, 150 kg N + 80 kg P + 100 kg K/ha + 5.62 kg Zn/ha with green manuring of *Sesbania* (3.3:1) while farmer practice *i.e.* 250:172:180 kg/ha NPK without soil test (2.8:1) was recorded.
- **Performance of wheat varieties in different locations of Lucknow district:** Farmers of Lucknow district mainly grow non-fortified variety. So, KVK, ICAR-IISR, Lucknow conducted an OFT to evaluate the performance of fortified variety *i.e.*, DBW-187 (Karan Bandana) in comparision to other varieties. DBW 187 also has better nutritional qualities which are reflected by maximum Mn (52.1 ppm), Cu (5.32 ppm) and Fe content (50.3 ppm) and best Zn content (43.7 ppm) in comparison from others.
- **Performance evaluation of broccoli varieties:** Farmers of Lucknow district grow broccoli for high remuneration. They grow number of varieties; which give less monetary returns. KVK, ICAR-IISR, Lucknow conducted an OFT to evaluate the performance of different varieties of broccoli as compared to farmers used variety.
- **Thrips management in mango orchard:** Mango is an important crop of Lucknow district. The number of insects-pests infect mango orchard, of which, thrips are a serious problem. This insect sucks the sap of new foliage due to which new leaves are dried and plant growth gets checked. So, for their management, farmers used many number of pesticides but did not get satisfactory results. So, keeping the facts, an OFT was conducted to assess the effect of Acetamiprid 20SP against thrips as compared to different chemical pesticides used at village Antgarhisaura of Mall block. Result showed that thrips incidence reduced upto 5%.
- **IPM in paddy crop:** In *Kharif* season, major area is covered under paddy crop in Lucknow district. This crop has high incidence of different insects like hoppers (Brown plant hopper, green leaf hopper, white backed plant hopper), gundhi bug and yellow stem borer *etc.*, which affected crop growth and yield also. So, KVK, ICAR-IISR, Lucknow conducted an OFT on evaluation of IPM for overcoming the problems in paddy crop. Result showed that treatment T2- Profenophos 50 EC @ 1 ml/lit water + Yellow sticky trap (10 No.) + Pheromone trap (10 No.) showed insect incidence up to 4.5% and yield was 68.98 q/ha . Cost benefit ratio of demonstration plot and farmers practice were 2.99:1 and 2.78:1.
- **Evaluation of different methods of button mushroom composting:** Farmers generally use long method of preparation of button mushroom compost in Lucknow district due to which their fruiting time is reduced and they get less return as compared to crop potential. So, the KVK, ICAR-IISR, Lucknow conducted an OFT programme to assess the method of button mushroom composting at village Rambagh (Amethi) of Goshaiganj block of Lucknow district. Results are awaited.
- **Early planting of cucurbits in potato crops:** Relay cropping system is also the system of growing different crops on the same land within a year but in this system, succeeding crop is sown/planted before the preceding crop is ready for harvest. The objective of on-farm trial was to maximise the resource use (soil, water, sunlight, vegetation, humans and animals) and achieve it through identification of crop adaptation for maximum productivity, based on soil, climate and management strategy. Keeping in view the above facts, an OFT of relay cropping system with potato and cucurbits was conducted at farmer's field. The seeds of cucurbits *viz.* bottle gourd, cucumber and pumpkin were grown by forcing in poly-low-tunnels during December and planted in the month of January in standing crop of potato. The results

showed that the first picking of fruits in cucurbits was 20-24 days early as compared to farmers practice. However, early yield was 131.7 q/ha in cucumber, 138.9 q/ha in pumpkin and 137.5 q/ha in bottle gourd which fetches higher remuneration ₹ 1,18,566.0/ha, ₹ 1,11,104.0/ ha and ₹ 1,10,020.0/ ha in cucumber, pumpkin and bottle gourd, respectively due to higher price during early harvesting as compared to farmers practice. The overall benefit cost ratio 1:4.05, 1: 4.41 and 1: 4.27 was calculated by planting of cucurbits with potato as relay cropping in comparison with farmers practice of sole cultivation of cucurbits at main season.

- **Disease management in vegetable pea:** Vegetable pea in an important vegetable crop of Lucknow district. Root rot and powdery mildew are important diseases, which severely affect this crop. Generally, farmers do not use any control measures for their management. So, the evaluation of efficacy of different fungicides was done in vegetable pea for overcoming the problems. Results showed that seed treatment (*Trichoderma viridae* @ 5 gm/kg seed) and spray of wetable sulphur (3.0 gm/lit.) showed root rot and powery mildew reduced upto 10% and 17-18% and increased the yield by 16.64%. Cost: benefit ratio of demonstration plot and farmers practice were 2.18:1 and 1.60:1.
- **Preservation of vegetable pea:** Green peas are very popular and they are used along with other vegetables in many vegetarian and continental dishes. Thus, apart from household demand, there is a continuous demand from restaurants, *dhabas*, caterers and canteens. Green peas are available for around 5 months during winter season only. Hence, if they are made available even during off-season, there is a good market for them. A small scale unit with lower overheads can offer competitive prices. Keeping in view of the above points, KVK, ICAR-IISR, Lucknow conducted on-farm trial to assess the feasibility of preservation of vegetable green pea through blanching techniques as compared with marketing of green pod of vegetable pea. The on-farm trial was conducted at ten farmers' households at Lucknow district. The results highlighted that blanching pea was able to attain olive green colour and peas were stored in deep freezer for one year with original taste. The economics of vegetable green pea preservation was calculated and the benefit cost ratio was 1.5:1.
- **Performance of sugar rich green fodder round the year:** To enhance the milk production in Lucknow district, there is a need to provide sugar rich green fodder availability round the year to milch animals. So, an OFT was conducted to see the performance of different combinations of cropping system. The results revealed that Sweet sorghum (July to September) – *Barseem* (November to February) and Sugar beet (March to June) provided green fodder (300 days) and per cent increase in milk was 24% due to sugar rich fodder followed by farmers practice, *Barseem-Jwar*-M.P. *Chari* (228 days) cropping system.

Frontline demonstrations (FLDs) conducted

Frontline demonstrations on oilseed crops

Crop	Thematic area	Technology demonstrated	Variety	No. of farmers	Area (ha)	Yield (q/ha)				% increase in yield	Economics of demonstration (₹/ha)				Economics of check (₹/ha)			
						Demo			Check		Gross cost	Gross return	Net return	BCR (R/C)	Gross cost	Gross return	Net return	BCR (R/C)
						High	Low	Average										
Sesamum	ICM	Improved Variety	Gujarat-1	76	10	5.8	4.9	5.4	3.8	29.6	24084	39457.8	15373.8	1.6:1	18509.8	27666.6	9256.8	1.4:1
Mustard	ICM	Improved variety+ fertilizer+NPKS:40:60:80: 20 +Insecticide Imidachloprid @ .3 ml/l	Giriraj	120	28	17.3	11.4	14.35	11.3	21.25	38500	66727.5	28227.5	1.73:1	33500	52545	19045	1.56:1
Mustard	ICM	Improved variety	RH-749	87	20	17	14	15.5	11.6	25.16	30000	78275	48275	2.6:1	30000	58580	28580	1.9:1

Frontline demonstrations on pulse crops

Crop	Thematic area	Technology demonstrated	Variety	No. of farmers	Area (ha)	Yield (q/ha)				% increase in yield	Economics of demonstration (₹/ha)				Economics of check (₹/ha)			
						Demo			Check		Gross cost	Gross return	Net return	BCR (R/C)	Gross cost	Gross return	Net return	BCR (R/C)
						High	Low	Average										
Chickpea	ICM	Improved variety N.P.:20:40	GNG-2144	55	10	17.5	11.3	14.91	10.4	30.25	28500	72686.3	44186.3	2.55:1	25900	50700	24800	1.96:1
Blackgram	ICM	Improved variety N.P.:15:40	PU-31	135	20	10.5	8.6	9.5	6.2	34.7	32775	59850	27075	1.8:1	23659.2	39060	15400.8	1.6:1

Frontline demonstrations on other crops

Category & crop	Thematic area	Name of the technology	No. of farmers	Area (ha)	Yield (q/ha)				% change in yield	Other parameters		Economics of demonstration (₹/ha)				Economics of check (₹/ha)			
					Demo			Check		Demo	Check	Gross cost	Gross return	Net return	BCR (R/C)	Gross cost	Gross return	Net return	BCR (R/C)
					High	Low	Average												
Paddy	IPM	Pheromone trap, sticky trap and Insectcide (Profenophos 50%)	39	10	75.6	64.3	69.63	61.3	12			44750	135082	90322	3.02:1	43550	118922	75372	2.73:1
Wheat	ICM	Improved variety HD-2967 NPK:120:60:40	1	0.5	48.9	42.3	44.23	36.63	17.2			34560	81383.24	6823.2	2.35:1	35550	67399.2	31849.2	1.89: 1
Wheat	ICM	Improved variety (DBW-187)	334	63.35	57	42	49.5	39	21.2			30000	100237.5	70237.5	3.34:1	32000	70200	38200	2.1: 1
Maize	ICM	Improved variety (Dekalb-9144)	18	5	53.7	48.8	50.9	38.8	23.77			38500	95183	56683	2.47:1	36000	72556	36556	2.0:1
Maize	ICM	Improved variety (Dekalb-8181)	16	5	45.6	38.7	41.7	38.8	6.95			37500	77979	40479	2.1:1	36000	72556	36556	2.0:1
Horticulture crops																			
Potato	IPM	Yellow sticky trap, spray of insecticide (Acetamepride 20%), Fungicide (Propeneb 70 WP)	7	2	355.6	325.8	339.9	305.0	11.44			125000	408000	283000	3.26	155000	366000	211000	2.36
Bottle gourd	IPM	Use of fruit fly trap (10 trap/ha.) through fruit fly trap	12	5	422.4	350.5	393.28	273.8	30.4	FFI:5.5	FFI:15.7	64250	196640	132390	3.06:1	62750	136900	74150	2.18: 1
Mango	IPM	Spray of Lamdacylothrien 5%	4	2	124.2	116.3	120.15	103.7	13.7			82500	180225	97725	2.18:1	83800	155550	71750	1.8:1
Broccoli	ICM	Improved variety (Fantasy F-1) NPK:100:80:60	10	1	210.6	196.5	205.4	134.3	34.6	Head weight: 0.7-1.1kg	Head weight: 0.6-0.8kg	95440	369720	274280	3.9:1	99700	241740	142040	2.4: 1
Cauliflower	ICM	Improved variety (Madhuri)	10	0.5	353.5	295.5	340.5	298.8	12.2	Head weight: 1.2-1.6kg	Head weight: 1.1-1.4kg	102000	238350	136350	2.3	105500	209160	142040	2.0
Chilli	ICM	Improved variety (Surymukhi)	10	0.5	135.6	122.5	131.5	115.5	12.2	High Pungrncy	Medium Pungrncy	95500	236700	141200	2.5	98800	173250	142040	1.8
Brinjal	ICM	Improved variety (Navkiran)	10	1	335.5	315.9	320.8	240.5	25.0			91250	256640	165390	2.8	98900	192400	142040	1.9
Tomato	ICM	Improved variety (US-2853)	14	1	623.5	585.6	590.5	514.2	12.9	-	-	175950	413350	237400	2.3	197700	359940	206140	1.8
Tomato	ICM	Improved variety (US-2853)	10	5	623.5	585.6	590.5	514.2	12.9	Shelf life: Very good	Shelf life: Good	126950	295250	168300	2.3	197700	359940	206140	1.8
Vegetable pea	ICM	Hybrid variety (Kashi Uday)	42	5	79.6	68.9	75.62	62.5	17.3	-	-	43500	136116	92616	3.1	48600	112500	46850	2.3
Vegetable pea	ICM	Hybrid variety (Kashi Uday)	108	10	85.5	69.5	78.4	62.8	19.9			49700	117600	67900	2.4	48600	94200	46850	1.9
Onion	ICM	Agrifound Light Red, Combined application of 110:40:60:20 kg NPKS along with 15 t FYM	34	1	295.5	265.8	272.8	215.8	20.9			65500	136400	70900	2.1	69000	107900	142040	1.6
Fodder crops																			
Fodder Sorghum Multicut	ICM	Improved variety (UPMC-503)	68	10	1380	1760	1660	1230	26.03			125000	398000	273000	3.2:1	155000	369000	214000	2.4:1
Barseem	ICM	Improved variety (BL-42)	186	10	926.1	754.5	842.8	560	33.5	--	--	217021	421400	204379	1.94:1	144200	224000	79800	1.5:1
Perennial grasses	ICM	Napier-3108	5	0.5	890	760	865	585	32.4	-	-	29830	129750	99920	4.3:1	37500	87750	50250	2.3:1
Oat	ICM	Improved variety (Kent)	19	5	480	390	435	340	21	-	-	30000	282750	252750	9.4:1	30000	221000	141000	7.3:1

Frontline demonstrations on livestock

Category	Thematic area	Name of the technology demonstrated	No. of farmers	No.of units (Animal/ poultry/ birds, *etc*)	Major parameters		% change in major parameter	Other parameter		Economics of demonstration (₹)				Economics of check (₹)			
					Demo	Check		Demo	Check	Gross cost	Gross return	Net return	BCR (R/C)	Gross cost	Gross return	Net return	BCR (R/C)
Deworming	Endoparasite management	All clear: Fenbendazole BP (vet) 3g	31	31	Endoparasite controlled 100%	Endoparasite controlled 15%	85%	--	--	--	--	--	--	--	-	--	--

Frontline demonstrations on other technologies

Category and crop	Thematic area	Name of the technology demonstrated	No. of farm-ers	No. of units	Yield		% change in yield	Other parameters		Economics of demonstration (₹/ha)				Economics of check (₹/ha)			
					Demon-stration	Check		Demo	Check	Gross cost	Gross return	Net return	BCR (R/C)	Gross cost	Gross return	Net return	BCR (R/C)
Kitchen gardening	ICM	NKG	200	200	Result Awaited		-	-	-	-	-	-	-	-	-	-	-
Roof top gardening	ICM	RTG	86	86	Result Awaited		-	-	-	-	-	-	-	-	-	-	-

B. Training programmes: Krishsi Vigyan Kendra has conducted 105 training programmes for participating farmers and farm women, rural youth and extension funtioneries on various topics with an objective to improve skill and upgrade their knowledge and change the attitude of farmers for adoption of technologies. All training programmes were fully skill oriented and smoothly conducted following the principles of "Learning by doing".

Clientele	No. of courses	Male	Female	Total participants
Farmers & farm women	87	1525	616	2141
Vocational trainings	10	173	41	214
In-service trainings	2	51	2	53
Sponsored training	6	62	2	64
Total	**105**	**1811**	**661**	**2472**

C. Other extension activities

Activity	No. of programmes	No. of farmers	No. of extension personnel	Total
Advisory services (Mobile)	3250	70711	12	70723
Field day	4	82	6	88
Group discussions	25	494	0	494
Kisan goshthi	38	4271	174	4445
Film show	5	768	0	768
Kisan mela	6	1785	0	1785
Scientists' visit to farmers field	273	2583	22	2605
Method demonstrations	274	1502	9	1511
Celebration of important days	3	346	47	393
Special day celebration	5	604	38	642
Lecture delivered	148	5784	221	6005
Others	10	1235	120	1355
Total	**4041**	**90165**	**649**	**90814**

ii. Publications

Particulars	Number
Research paper	1
News paper coverage	8
Popular articles	8
Technical reports	30
Training manual	1
Radio talks	09
TV talks	02
Total	**59**

iii. Soil sample analysis

Samples	No. of samples	No. of farmers	No. of villages
Soil samples on grid basis	272	272	19

D. Seed and planting material production

i. Seed production

Crop	Quantity (q)
Cereal (Wheat)	140.75
Oilseed (Mustard)	14.50
Total	**155.25**

ii. Planting material production

Crop	Quantity (No.)
Fruit saplings	54,000
Vegetable seedlings	64,617
Root slips of different perennial fodder grasses	5,800
Total	**1,24,417**

iii. Production of bio-products and produce

Bio-products	Quantity
Vermicompost	35,000 kg
Earth worms	06 kg
Mushroom	170 kg
Cow milk	4514 litre

CHAPTER 12

Krishi Vigyan Kendra, Lakhimpur Kheri

1. Training Programmes

Clientele	No. of Courses	Male	Female	Total participants
Farmers & farm women	30	681	208	889
Rural youths	08	216	03	219
Extension functionaries	01	29	0	29
Total	**39**	**926**	**211**	**1137**

2. Frontline Demonstrations

Enterprise	No. of Farmers	Area (ha)	Units/Animals
Cereals	04	2.0	-
Vegetables	15	1.5	-
Other crops	05	2.0	-
Livestock & Fisheries	25	-	850 Birds

3. Technology Assessment & Refinement

Category	No. of Technology Assessed & Refined	No. of Trials	No. of Farmers
Technology Assessed			
Crops	04	26	22
Livestock	02	06	06
Total	06	32	28

4. Extension Programmes

Category	No. of Programmes	Total Participants
Extension activities	117	3010
Other extension activities	32	1011
Total	**149**	**4021**

5. Soil, Water & Plant Analysis

Samples	No. of Beneficiaries
Soil	100 at IISR

6. Seed and Planting Material Production

Seed/Planting material	Quintal/Number	Value (₹)
Seed (q)	24	31,000.00
Planting material (No.)	27250	27,250.00

7. Publications

Category	Number
Book chapters	01
Extension folder/Bulletin	02
Proceedings	01

CHAPTER 13

Services to the Industry

Contract Research Project

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, 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 13.1.

Table 13.1. Memorandum of Understanding for Contract Research

Contracting party	Contract research
Acadian Seaplants Ltd., Goregaon West, Mumbai	Evaluation of the effect of SoliGro GR on growth and yield of sugarcane (S.R. Singh, M.K. Tripathi, A.P. Dwivedi and A.D. Pathak, 09/19-09/21, Budget: ₹ 10.0 lakh)
Agrinos India Pvt. Ltd., New Delhi	Assessing efficacy of Narmada PROM (Phosphorus rich organic manure) as an organic source of P on soil quality and productivity of cane & sugar in Indian sub-tropics (S.N. Singh, A.D. Pathak, V.K. Singh, S.R. Singh, M.K. Tripathi and A.P. Dwivedi; 2019-2022, Budget: ₹ 10.0 lakh)
ADAMA Private Limited, Hyderabad	Bio-efficacy of ADM. 00903. I. 2. B against early shoot borer and its effects on bio-agents and sugarcane crop (MR Singh A Baitha; Budget ₹ 10.0 lakh)
Bayer Crop Science Ltd., Mumbai	Bio efficacy and phytotoxicity evaluation of Solomon 300 OD against black bug infestations in sugarcane (Y.E. Thorat, D.N. Borase, S.N. Sushil, 10/21-09/23, Budget: ₹ 13.0 lakh)
BASF India Ltd., Navi Mumbai	Bio efficacy and phytotoxicity evaluation of BAS 43311H against broad-leaved weeds and sedges in sugarcane and its effect on succeeding crop (Pravaranagar Centre), (D.N. Borase, Y.E. Thorat; 01/21-08/23, Budget: ₹ 20.0 lakh)
BASF India Pvt. Ltd., Mumbai	Bio-efficacy and phytotoxicity evaluation of BAS 43311 H against broad leaved weeds and sedges in sugarcane and its effect on succeeding crop" (Lucknow Centre) (S.K. Yadav, S.K. Shukla, Lalan Sharma, V.P. Jaiswal, Mona Nagargade and S.K. Holker, 2020-2021, Budget: ₹ 20.0 lakh)
BASF India Pvt. Ltd., Mumbai	Evaluation of bio efficacy and phytotoxicity of pre-emergent application of two herbicide products BAS 781 02 H and BAS 822 01 H against weeds in sugarcane and its effect on succeeding crop (S.K. Yadav, M.K. Tripathi, S.K. Shukla, A.D. Pathak, S.K. Holker, D.N. Borase and Y.E. Thorat, 04/18-03/21, Budget: ₹ 15.0 lakh)
Biostadt, Mumbai	Evaluation of Biocane granules on crop health and yield in sugarcane (A.P. Dwivedi, 2021-2022, Budget: ₹ 5.0 lakh)
FMC India Pvt. Ltd.	Efficacy of F4337-500 SC against major insect pests of sugarcane. (S.N. Sushil, Sharmila Roy and A Baitha; Budget: ₹ 15.0 lakh)
FMC India Pvt. Ltd.	Efficacy of F4337-500 g/I SC against major insect pests of sugarcane (Y.E. Thorat, D.N. Borase, S. N. Sushil, 7/21-6/23 Budget: ₹ 15.0 lakh)
FMC India Pvt. Ltd.	Efficacy of E 2Y45 600 SC against major insect pests of sugarcane. (S.N. Sushil, Sharmila Roy and A Baitha; Budget: ₹ 15.0 lakh)
IPL Biological Ltd., Gurugram	Evaluation of *Pseudomonas fluorescens* 1.0% W.P (Strain No. IPL/PS/01) against pokkah boeng and *Trichoderma viride* 1.0% W.P (Strain No. IPL/VT/101) against red rot in sugarcane (Dinesh Singh, 04/21-03/23, Budget: ₹ 15.0 lakh)
IPL Biological Ltd., Gurugram	Bio-efficacy and evaluation of biofertilizer cane master (*Gluconacetobacter diazotrophicus* sp) in sugarcane crop (V.P. Jaiswal, Lalan Sharma, S.K. Shukla, A.P. Dwivedi and A.D. Pathak, 10/20-12/22, Budget: ₹ 10.0 lakh)
ISK Biosciences India Pvt. Ltd., Delhi	Bio-efficacy evaluation of SL-160 25% WG herbicide against weed complex of sugarcane (V.P. Singh, K.K. Singh, Dileep Kumar and A.D. Pathak; 03/20 – 12/ 22, Budget: ₹ 12.0 lakh)
Narmada Bio-Chem. Ltd., Ahmadabad	Assessing efficacy of Narmada PROM (Phosphorus rich organic manure) as an organic source of P on soil quality and productivity of cane & sugar in Indian sub-tropics (S.N. Singh, A.D. Pathak, V.K. Singh, S.R. Singh, M.K. Tripathi and A.P. Dwivedi, 03/19-07/22, Budget: ₹ 10.0 lakh)
Patanjali, Haridwar	Efficiency and evaluation of *Patanjali jaivik kranti* and *Patanjali Dharti ka Chaukidar* in sugarcane (V.P. Jaiswal, S.K. Shukla and Lalan Sharma, 02/21-01/23, Budget: ₹ 10.0 lakh)

Contracting party	Contract research
Sirius Minerals Ind. Pvt Ltd.	Efficacy of Poly-4 on growth behaviour, yield attributes and soil health of sugarcane (autumn) (M.K. Tripathi, S.K. Shukla, S.R. Singh, A.P. Dwivedi and A.D. Pathak, 10/18-03/21, Budget: ₹ 33.0 lakh)
United Phosphorus Ltd., Mumbai	Bio-efficacy evaluation of GPI 818 & GPI 418 against major insect pests in sugarcane. (S.N. Sushil, Sharmila Roy and A. Baitha; Budget: ₹ 20.0 lakh)
United Phosphorus Ltd., Mumbai	Bio efficacy and phytotoxicity evaluation of GPI 1820 against early shoot borer, white grub and termite infesting sugarcane (D.N. Borase, Arun Baitha, S.N. Sushil, Y.E. Thorat, 01/21-08/23 Budget: ₹ 13.0 lakh)
United Phosphorus Ltd., Mumbai	Bio-efficacy and phytotoxicity evaluation of UPST 119 against early shoot borer, white grubs and termites infesting termites (D.N. Borase, S.N. Sushil, Arun Baitha, Y.E. Thorat, 02/21-01/23, Budget: ₹ 15.0 lakh)
United Phosphorus Ltd., Mumbai	Bio-efficacy and phytotoxicity evaluation of GPH 1521 against broad-leaved weeds and sedges in sugarcane and its effect on succeeding crop (D.N. Borase, S.K. Yadav, Dileep Kumar, Y.E. Thorat, 03/21-02/23, Budget: ₹ 18.0 lakh)
United Phosphorus Ltd., Mumbai	Evaluation of PIX 10042 76.75% WG against important weeds of sugarcane, and its effect on soil micro flora, succeeding crop and yield (A.P. Dwivedi, S.K. Shukla, V.P. Jaiswal, A.D. Pathak and M.K. Tripathi, 2019-2022, Budget: ₹ 15.0 lakh)
United Phosphorus Ltd., Mumbai	Bio-efficacy and phytotoxicity of fungicide "SAAF Gr (Carbendazim 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)
United Phosphorus Ltd., Mumbai	Bio-efficacy and phyto-toxicity evaluation of UPH 114 b against weeds in sugarcane (V.P. Jaiswal, V.P. Singh, Lalan Sharma and S.K. Shukla, 02/19-08/21, Budget: ₹ 15.0 lakh)
VSI, Pune	Bio-efficacy testing of entomopathogenic fungi as a biopesticide against white grubs and whitefly in sugarcane (Y.E. Thorat, D.N. Borase, S.N. Sushil, 02/21-01/23, Budget: ₹ 5.0 lakh)
Zydex India Pvt. Ltd., Vadodara	Effect of Zytonic M and microbial consortia on sustaining soil health and sugarcane yield in subtropical India (M.K. Tripathi, Mona Nagargade, S.K. Shukla, V.P. Jaiswal and A.D. Pathak, 04/20-03/22, Budget: ₹ 6.00 lakh)

CHAPTER 14

Human Resource Development

Online/Virtual Training Programme on "Capacity Building Programme" for all the Staff of ICAR-IISR, Lucknow

A three days "Online/Virtual Training Programme on Capacity Building" for all the Staff of ICAR-IISR, Lucknow" was organized at the Institute during March 4-6, 2021 under the Human Resource Development Unit with Dr. Sangeeta Srivastava, Principal Scientist & HRD Nodal Officer as Course Director and Sri S.K.Singh, Senior Administrative Officer and Dr. Sukhbir Singh, HRD Co-Nodal Officer as Course Coordinators.

The training programme was inaugurated by Dr. A.D. Pathak, Director, IISR, Lucknow on 4th March, 2021. The various topics related to Hands out on e-Office, Fundamentals of GFR-2017, Processing of tenders & CVC guidelines, Effectiveness at workplace, IPR Issues, Enhancement of Communication Skill, Motivation & Team Work, Introduction to SAS Software for Data Analysis and Hands on Training on its Application were covered during these three days. The lectures were delivered by Dr. S.K. Soam, Joint Director, ICAR-NAARM, Hyderabad; Dr. R.V.S. Rao, I/c Head, HRD Division, ICAR-NAARM, Hyderabad; Sh. S.K. Singh, SAO, Drs. Sangeeta Srivastava, Rajesh Kumar, Sukhbir Singh, Principal Scientists & others from ICAR-IISR, Lucknow. All the staff participated in the training programme.The training programme was concluded with vote of thanks by Sh. Saroj Kumar Singh, Sr. Administrative Officer & Course Coordinator.

Training Programme on Administrative and Financial Matters

A four day "Training Programme on Administrative and Financial Matters"was organized by the ICAR-Indian Institute of Sugarcane Research, Lucknow during March 08-11, 2021 under the Human Resource Development Policy of the Council. The entire training programme was designed & coordinated by Sh. S.K. Singh, SAO as Master Trainer & Course Director, Dr. Sangeeta Srivastava, HRD Nodal Officer & Course Coordinator & Sh. A.K. Sharma, AO & Co-Course Coordinator who were the key lecturers. The various topics related to administration and finance like, Financial Management, e-Procurement, GeM, CCS (Conduct) Rules, CCS (CCA) Rules, Departmental Proceedings, Preventive Vigilance, Reservation in Services & Roster, Career Advancement Schemes, Technical Assessment, Right to Information Act-2005,

Motivation, Team Work *etc.* were taken up. A total of 34 participants participated in the training programme.

Training Programme on Establishment Matters for LDC and UDC of ICAR

Five days "Training Programme on Establishment Matters for LDC and UDC of ICAR" was organized through Online Mode by the ICAR-IISR, Lucknow in collaboration with HRM Unit of ICAR HQ during November 15-20, 2021. The training programme was designed & coordinated by Sh. S.K. Singh, Master Trainer & Course Director; Smt. Anjali Sharma, US, HRM & Course Coordinator and Sh. R.K. Yadav, AAO & Co-Course Coordinator. The lectures were delivered by Sh. S.K. Sinha, CAO; Sh.Kumar Rajesh, CAO; Sh. S.K. Singh, Sr.AO; Shri I.B. Kumar, SAO; Shri N.K. Jha, SAO; Sh. Shitanshu Kumar, SAO; Sh. Imtiaz Ahmad, Asst Registrar; Sh. V. Ganesh Kumar, SAO; Sh. Umesh Gahlot, SO; Sh. Sohan Lal, SO & others. The various topics related to Establishment like, Governance in ICAR, Noting & Drafting, Office Procedure, Financial Management, CCS (Conduct) Rules, Preventive Vigilance, Scientific & Technical Assessment, Leave Rules, ACP/MACP Guidelines, Right to Information Act-2005, Time Management, Team Work *etc.* were covered during these five days. More than 40 participants participated in the training programme.

Training Programme on Establishment Matters for Administrative Staff

A four day "Training Programme on Establishment Matters for Administrative Staff" was organized by the ICAR-Indian Institute of Sugarcane Research, Lucknow during December 20-23, 2021 under the Human

Resource Development policy of the C ouncil. The entire training programme was designed & coordinated by Sh. S.K.Singh, Master Trainer & Course Director; Sh. A.K. Sharma, AO & Course Coordinator and Sh. Ravi Bhadra, FAO & Co Course Coordinator. Shri Kanhaiya Chaudhary, Shri P.K. Jain, Dr. Pankaj Kumar, Shri S.K. Singh, Shri I.B. Kumar, Shri N.K. Jha, Shri Neeraj Tahiliani and Shri Sumit Vishwakarma delivered lectures during the training on the various topics related to establishment matters like, Pay Fixation, Reservation in Services, Reservation Roster, Contract Management in ICAR, Record Management, Effective Execution, Team Work, Time Management, e-Office, DPC Guidelines, Promotional Avenues, Technical and Scientific Assessment *etc.* A total of 48 participants from IISR Lucknow; NBFGR, Lucknow; CISH, Lucknow; IIPR, Kanpur and IGFRI, Jhansi participated in this training programme.

Training attended

Name	Training Programme	Venue/Organizer	Date
Er. V.A. Blessy	Professional attachment training as a part of FOCARS	ICAR-CIAE, Bhopal	November 11, 2020 - February 11, 2021
Mr. Aalok Shiv	Professional attachment training as a part of FOCARS	ICAR-NIPB, New Delhi	November 20, 2020 - March 7, 2021
Dr. Rajesh U. Modi	Professional attachment training on 'Artificial Intelligence/Deep learning'	ICAR-CIAE, Bhopal, Madhya Pradesh	December 07, 2020 - March 06, 2021.
Dr. S.S. Hasan	Generic Online Training in Cyber Security	CDAC, Hyderabad	January 5, 2021
Dr. Rajeev Kumar	Training on Research Skills and Refinement of Technology	ICAR-IIHR, Bengaluru	January 18-20, 2021
Mr. Dhirendra Kumar	Online Training Programme under ICAR-DoF Convergence on "Fisheries and its Management"	Online	February 4, 2021
Er. V.A. Blessy	Training in Automation in Micro-irrigation System	Department of SWCE, College of Agricultural Engineering, JAU, Junagadh	February 9-13, 2021
Dr. Rajesh U. Modi	Online Workshop on Accelerated Data Science	IIT, Kharagpur, West Bengal and NVIDIA under the aegis of National Supercomputing Mission	February 20-21, 2021
Dr. S.S. Hasan	Online Programme on Data Visualization in Agribusiness and Agricultural Research	ICAR-NAARM, Hyderabad	February 22-27, 2021
Dr. S.S. Hasan	Online Training Programme on "Geo-informatics in Agriculture using Open-Source Data and Analysis Platforms	ICAR-IARI, New Delhi	March 1-5, 2021
All the staff of the ICAR-IISR, Lucknow	Capacity Building Programme for IISR Staff	ICAR-IISR, Lucknow	March 4-6, 2021
Dr. Sanjeev Kumar (Agri. Biotech.)	Competency Training for DBT-ATL staff under NCS-TCP	ICAR-NIPB & IARI, New Delhi	March 8-12, 2021
Dr. S.S. Hasan and Dr. Rajesh U. Modi	Online Training Programme on Applications of Artificial Intelligence and Cloud Computing in Agriculture	ICAR-NAARM, Hyderabad, Telangana	March 15-20, 2021
Dr. Sangeeta Srivastava	Generic On-line Training Course on Cyber Security	Ministry of Electronics & Information Technology, New Delhi and C-DAC, Hyderabad	March 25, 2021
Dr. Y.E. Thorat	Online training in 'Cybersecurity for Central Government Ministries/Department'	Ministry of Electronics and Information Technology, Govt. of India	April 29, 2021
Dr. Sangeeta Srivastava	Virtual training on "Implementation and Use of Agricultural Research Management System (ARMS)"	ICAR-IASRI, New Delhi	June 8, 2021
Mrs. Manisha Saini	Professional Attachment Training as a part of FOCARS	ICAR-NIPB, New Delhi	June 14 – September 13, 2021
Dr. Santeshwari	Online Training Programme	NAHEP-Chandra Shekhar Azad University of Agriculture & Technology, Kanpur	June 21-22, 2021
Dr. L.S. Gangwar	MDP on Business Plan Development and Accelerating FPOs/FPC	ICAR-NAARM, Hyderabad	June 21-26, 2021
Dr. A.K. Sah	Training on "How to overcome stress"	NAHEP, ICAR, New Delhi	June 28, 2021

Name	Training Programme	Venue/Organizer	Date
Dr. Santeshwari	Online Training Programme	NAHEP-Chandra Shekhar Azad University of Agriculture & Technology, Kanpur	July 6-7, 2021
Dr. A.K. Dubey, Dr. Deepak Rai, Dr. Veenika Singh, Dr. R.K. Singh, Dr. S.K. Pandey & Dr. V.N. Singh	Capacity Development Programme for SMSs of KVKs	ICAR-ATARI, Kanpur	July 9, 2021
Dr. Rajesh Kumar, Dr. S.S. Hasan and Sh. Atul Kumar Sachan	Two days course on ArcGIS : Introduction to GIS	Online	July 12-13, 2021
Er. V.A. Blessy	Training on Rainfall Data Analysis Using Different Package of R Software	KCSTE-CWRDM, Kozhikode, Kerala	July 12-22, 2021
Mr. Aalok Shiv	Training on "Plant Genetic Resources Management and Utilization" (Online Mode)	ICAR-NBPGR, New Delhi	July 19-Aug. 01, 2021.
Dr. A.K. Dubey, Dr. Deepak Rai, Dr. Veenika Singh, Dr. R.K. Singh, Dr. S.K. Pandey, Dr. V.N. Singh and Sh. Ram Lakhan	Online Training Kisan Sarathi organized by IT Unit, ICAR-IASRI, New Delhi	ICAR-IASRI, New Delhi	July 24, 2021
Dr. Sanjeev Kumar (Agri. Biotech.)	Generic Online Training in Cyber Security	Ministry of Electronics & Information Technology, New Delhi and C-DAC, Hyderabad	July 29, 2021
All the Scientists of Division of Crop Production and Dr. S.K. Yadav	Integrated *Parthenium* Management	ICAR-DWR, Jabalpur	August 19, 2021
Mr. Dharmendra Kumar	*Sukhsmjeev Technology Anuprayog Par Prayogik Parikshan under Biotech Kisan Pariyojana*"	ICAR-NBAIM, Mau	August 31 - September 4, 2021
Dr. S.K. Pandey	Online training programme on Effective Extension Methods for Upscaling and Outscaling of Wheat and Barley Production Technologies	ICAR-IIWBR, Karnal	September 1-10, 2021
Dr. M. Swapna	Generic On-line Training Course on Cyber Security	Ministry of Electronics & Information Technology, New Delhi and C-DAC, Hyderabad	September 16, 2021
Dr. Sanjeev Kumar (Agri. Biotech.)	Training for ISO 17025 -Level I (online) and ISO 17025 - Level II (Onsite)	NABL, Gurugram	September 23-25, 2021
Dr. M. Swapna	Training on 'Transcriptomic Data Analysis'	ICAR-IASRI, New Delhi	September 28-30, 2021
Mr. Aalok Shiv	Hands-on Training on CRISPR/Cas9 Mediated Gene Editing in Plants" (Online Mode)	Department of Plant Science, University of Hyderabad	October 03-10, 2021.
Dr. L.S. Gangwar	MDP on Priority Setting, Monitoring and Evaluation (PME) of Agricultural Research Projects	ICAR-NAARM, Hyderabad	October 25-30, 2021
Dr. Sangeeta Srivastava	Workshop on "Molecular Data Analysis through Bioinformatics Tools" in online mode	ANGRAU, Tirupati	November 1-10, 2021
Dr. Deepak Rai	Online training programme on Enhancing Resilience through Entrepreneurship	ICAR-NAARM, Hyderabad	December 6-10, 2021
Dr. Sangeeta Srivastava and Dr. Rajeev Kumar	Online Training on "SNP Mining, GWAS and Genomic Selection"	ICAR- IASRI, New Delhi	December 16-21, 2021
Dr. Sangeeta Srivastava	Online Training on "Sexual Harassment of Women at Workplace (Prevention, Prohibition and Redressal) Act 2013"	National Productivity Council, New Delhi	December 21-22, 2021

Training organized by Extension and Training Unit

Sr. No.	Duration	Topic	Sponsoring Agency	No. of Participants
1.	January 29-30, 2021	Sugarcane Production Technology for Doubling Farmers' Income	Ministry of Agriculture and Farmers Welfare, Government of India under NFSM	28 Officers
2.	February 23-27, 2021	Seedcane Production Technology and Certification	ATMA, State Agriculture Management Institute, Rehmankheda, Lucknow	35 Farmers
3.	March 01-02, 2021	New Techniques of Sugarcane Cultivation Practices	JDA, Govt. of Tripura	01 Officer
4.	March 09-10, 2021	Sugarcane Production Technology for Doubling Farmers' Income	Ministry of Agriculture and Farmers Welfare, Government of India under NFSM	25 Officers
5.	March 10 - April 10, 2021	RAWE Training	RAWE for B.Sc. (Ag.) Students of Mewar University, Rajasthan	01 Student
6.	March 21-22, 2021	Sugarcane Production Technology	KVK, Parsauni (East Champaran) and IISR, Lucknow	1,000 Farmers & Officers
7.	March 22-23, 2021 (Group I)	Sugarcane Production Technology for Doubling Farmers' Income	Ministry of Agriculture and Farmers Welfare, Government of India under NFSM	25 Officers
8.	March 22-23, 2021 (Group II)	Sugarcane Production Technology for Doubling Farmers' Income	Ministry of Agriculture and Farmers Welfare, Government of India under NFSM	25 Officers
9.	March 24-25, 2021	Sugarcane Production Technology for Doubling Farmers' Income	Ministry of Agriculture and Farmers Welfare, Government of India under NFSM	25 Officers
10.	March 26, 2021	Sugarcane Production Technology	DSD, Ministry of Agriculture and Farmers Welfare, Government of India, Lucknow	100 Farmers

Entrepreneurship training for promoting agri-business

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.

Entrepreneurship in operation and maintenance of sugarcane machine

As per RAC recommendation, a programme on entrepreneurship in sugarcane machine was initiated in association with Biswan sugar mill and an event was organized to demonstrate the operation of sugarcane machines in the farmers'; fields in Biswan mill zone area. A group of farmers was created to develop them as entrepreneur in machine maintenance and operation.

One day training-cum-visit organised

During the year 2021, a total of 41 nos. of one day training and visit programmes were organized at the Institute in which 909 farmers, 10 development personnel, 04 entrepreneurs, 535 students and 16 teachers acquired latest know-how in scientific cane cultivation practices, jaggery making, bio-fertilizer production, tissue culture and sugarcane machines.

Students visit under Inter-institutional HRD activities

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

Trainings organised by IISR BCC, Pravaranagar

- One-week training on "Sugarcane Research and Management" under RAWE (Rural Agricultural Work Experience) programme of College of Agriculture, Loni affiliated to MPKV, Rahuri was organized at Biological Control Centre, Pravaranagar from August 28 to September 3, 2021 for 25 students of B.Sc. (Agriculture) under the

Course Directorship of Dr. Y.E. Thorat and Course Coordinatorship of Dr. D.N. Borase.

- One-week attachment training of 28 students of B.Sc. (Agri) on "Sugarcane Research and Management" under RAWE (Rural Agricultural Work Experience) programme of College of Agriculture, Loni and College of Agriculture Baramati affiliated to MPKV, Rahuri at Biological Control Centre, Pravaranagar was conducted during September 4-10, 2021. Dr. D.N. Borase acted as Course Director and Dr. Y.E. Thorat acted as Co-Director.

- One-week attachment training of 30 students of B.Sc. (Agri) students on "Sugarcane Research and Management" under RAWE (Rural Agricultural Work Experience) programme of College of Agriculture, Maldad affiliated to MPKV, Rahuri was conducted at Biological Control Centre, Pravaranagar from September 11-17, 2021. Dr. D.N. Borase acted as Course Director and Dr. Y.E. Thorat acted as Co-Director.

Other training programmes organized

- One to two years ITI apprenticeship training was organised in the Division of Agricultural Engineering for trainees in different trades namely fitter, welder, electrician, refrigeration & air conditioning etc.

HRD facilities developed

Development and upgradation of networking and internet facilities

For improvement in Institute networking and internet facilities, up-gradation of networking has been initiated to change the old optical fiber cable with new one in all buildings in the campus of ICAR-IISR. A new separate line of optical fiber to Krishi Vigyan Kendra has also been installed to link KVK with the server of ICAR-IISR. Overall, more than 200 hundred nodes are functional for networking at the Institute.

Design and development of new website of ICAR–IISR

New website of ICAR–Indian Institute of Sugarcane Research, Lucknow has been developed based on Website development guidelines of GoI and ICAR. New website is bilingual, responsive and caters to various information being provided by Institute Division/Section. New website has been launched on ICAR data server with domain iisr.icar.gov.in. This website is more user friendly and has improved the functioning of the Institute. New Firewall facility has been established on Institute network to provide secured Internet services on Institute network.

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

A web based application, AICRP Reporter, has been developed to provide an effective data recording and reporting platform for 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.

Virtual platform facilities created and executed

Virtual platform facilities like Zoom, Google Meet and MS-Team were created and provided to the participants/users for conducting meetings, workshops and seminars. During Covid-19 period, meetings were organized through zoom software facility at ICAR-IISR, Lucknow during 2021 which helped in improving and executing research and development work of the Institute during pandemic in the country.

CHAPTER 15

Awards and Recognitions

Govt. of India Awards

- The Hindi magazine 'Ikshu' of ICAR-Indian Institute of Sugarcane Research, Lucknow was awarded the second prize under the *Rajbhasha Kirti Puraskar* for the year 2018-19 at the *Hindi Diwas* function organized at Vigyan Bhawan, New Delhi on September 14, 2021.

- Dr. Shiv Nayak Singh, Principal Scientist of the Institute and Dr. Ashwini Dutt Pathak, Director of the Institute were jointly awarded 3rd prize for the year 2020-21 at the *Hindi Diwas* function organized at Vigyan Bhawan, New Delhi on September 14, 2021, for the publication of the article on "Sugarcane cultivation in Maharashtra facing water crisis: Assessment and possible measures for sustainable production".

ICAR Awards

- Dr. Ajay Kumar Sah, Principal Scientist was awarded Swami Sahajanand Saraswati Outstanding Extension Scientist Award-2020 on the occasion of the 93rd Foundation Day and Award Ceremony organized by the Indian Council of Agricultural Research, New Delhi on July 16, 2021.

- *Ikshu* magazine of ICAR-Indian Institute of Sugarcane Research, Lucknow, was awarded the first prize of Ganesh Shankar Vidyarthi *Hindi Puraskar Yojana* 2020 in the category of large institutions of 'A' and 'B' region on the occasion of the online 93rd Foundation Day and Award Ceremony organized by the Indian Council of Agricultural Research, New Delhi on July 16, 2021.
- *Ikshu* magazine of ICAR-Indian Institute of Sugarcane Research, Lucknow received the second prize for the year 2019-20 under the Rajshree Tandon *Rajbhasha Puraskar* in the category of large institutions.

Professional Society Awards

- Dr. Sukhbir Singh received "ISAE Commendation Medal Award 2020" from Indian Society of Agricultural Engineers during the 55th Annual Convention of Indian Society of Agricultural Engineers held at Patna, Bihar on November 23-25, 2021.
- Dr. Sangeeta Srivastava received Sir T.S. Venkatraman Award for Outstanding Research in Sugarcane Agriculture for the biennium 2018-2019 by ICAR-SBI, Coimbatore on 25th October 2021.

- Dr. C. Gupta received Life Time Achievement Award -2020 for outstanding contribution in field of Agronomy in the International Seminar 2021 (Virtual on-line): Agricultural Sustainability for Doubling Income in Changing Climate Scenario and Market Challenges during Covid-19 (ASDICCSMC-2020) on April 10-11, 2021 at University of Allahabad, Prayagraj, jointly organized by ICAR-Agricultural Technology Application Research Institute, Kanpur; ICAR-Indian Institute of Sugarcane Research, Lucknow; University of Allahabad, Prayagraj and *Swadeshi Jagaran Manch, Krishi Shodh Evam Prashikshan Sasthan and Susanskriti*, Prayagraj, India.
- Dr. A.P. Dwivedi received Eminent Scientist Award for outstanding performance and lasting contribution in the field of Agronomy on occasion of International Seminar (Virtual) on Agricultural Sustainability for Doubling Income in Changing Climate Scenario and Market Challenges during Covid-19 (ASDICCSMC-2021) on April 10-11, 2021 held at University of Allahabad, Prayagraj.
- Dr. A.K. Sah received Incredible Scientist of India Award-2021 from Record Owner (www.recordowner.com).
- Dr. C.K. Gupta received 'Outstanding Scientist Award' from the Society of Tropical Agriculture, India during International Conference on Agriculture, Horticulture and Food Sciences held at Shimla during December 29-30, 2021.
- Dr. Ranjit Singh Gujjar received 'Excellence in Agricultural Research Award for Outstanding contribution in Plant Biotechnology'-2021 at International Conference on Innovative Approaches in Applied Sciences & Technology held at BBAU, Lucknow during December 3-5, 2021.
- Dr. S.K. Yadav received ISA Associateship 2020 Award recognized by Indian Society of Agronomy for outstanding contribution to Agronomy discipline.
- Dr. Shweta Singh received Smt. Guman Devi Verma Memorial Best Woman Scientist Award-2020 during ISMPP 41st Annual Conference and National e-Symposium on Innovative Approaches in Plant Health Management organized by Indian Society of Mycology and Plant Pathology, Udaipur and University of Horticultural Sciences, Bagalkot during January 28-30, 2021.
- Mr. Aalok Shiv received Young Scientist Award by Association of Plant Science Researchers, Official Organization of Plantica Foundation, Dehradun.
- Dr. Sanjeev Kumar (P.S.-Agri. Biotech.) was selected as 'Member' of National Academy of Sciences India (NASI) for the year 2021.

Best Ph.D. Thesis Award

- Dr. Rajesh U. Modi received Giuseppe '*Pellizzi Prize 2020*' an International Best PhD on Agricultural Mechanization along with award money of 800 Euros from Club of Bologna, Italy conferred at Bologna, Italy on October 22, 2021.

Fellows

- Dr. A. Baitha was elected as Life Fellow of The Entomological Society of India on June 30, 2021.
- Dr. Sanjeev Kumar (Agri. Biotech.) was conferred the 'Fellowship' of Indian Society of Vegetable Science (ISVS) for the year 2021.
- Dr. A.K. Mall was awarded ISGPB Fellow 2021 from Indian Society of Genetics and Plant Breeding.
- Dr. C.K. Gupta received 'Fellow Award' from Society for Scientific Development in Agriculture and Technology (SSDAT), Meerut, U.P. during International Conference GRISAAS-2021 held at SRKAU, Bikaner in virtual mode during December 13-15, 2021.

Excellence Award by the Institute on the occasion of 70th Foundation Day of ICAR-IISR, Lucknow on February 16, 2021

- Dr. S.K. Shukla received IISR Best Scientist Award 2021 for the outstanding research work at the Institute.
- A team comprising of Drs. S.K. Shukla, A.D. Pathak, Lalan Sharma, V.P. Jaiswal, Mrs. Asha Gaur, Mr. Abhay Kumar Srivastava and Mr. Raghvendra Tiwari was conferred ICAR-IISR Best Team Award for the outstanding team work.
- Mr. A.K. Sachan was awarded special award for assistance in organization of various meetings during Covid-2019.

- Dr Varucha Misra, YP II awarded Best Worker Award for outstanding contribution in Category-RA/SRF/JRF/YP.
- Dr. Rajesh Kumar and Dr. S.S. Hasan were awarded IISR Award for Creation of Infrastructural Facilities for outstanding work on development of facilities for virtual platform.

Best Paper Award

- Dr. Rajesh U. Modi received First Prize for Best Oral Paper Award in the National Conference on Role of Agricultural Engineering in Economic Development and Self-dependence during COVID-19 Situation held at ICAR-CIAE, Bhopal during July 28-29, 2021.
- Dr. C. Gupta was awarded the Best Oral Presentation Award (First Prize) for the paper entitled "Advance agro techniques for efficient water management in sugarcane under subtropical India" in the International Conference on Sugarcane Research: Sugarcane for Sugar and Beyond (CaneCon2021) held through virtual mode during June 19-22, 2021.
- Dr. A.P Dwivedi received the Best Paper Presentation Award for his paper entitled "Enhancing productivity and profitability of farmer's through sugarcane based Integrated Farming System in sub-tropical India" in International Seminar (Virtual) on Agricultural Sustainability for Doubling Income in Changing Climate Scenario and Market Challenges during Covid-19 during April 10-11, 2021.
- Dr. Rajesh U. Modi received the Best Poster Award in International Web-Conference on Smart Agriculture for Resource Conservation and Ecological Stability organized on October 29-31, 2021.
- Dr. S.K. Shukla received ISA Best Research Paper Award -2020 published in Indian Journal of Agronomy 65(1) for the paper entitled "Growth, nutrient accumulation and crop yields as influenced by crop residue recycling and *Trichoderma* inoculation in rice-wheat and sugarcane-ratoon-wheat cropping systems in subtropical India".

Office bearer of the professional societies

- Dr S.I. Anwar acted as Secretary of Lucknow Chapter of Indian Society of Agricultural Engineers (ISAE).

Editor

- Dr. Rajesh Kumar was elected Editor-in-Chief (Hony.) of Asian Sugar Journal published by The Asian Association of Sugarcane Technologists, Lucknow.
- Dr. Sangeeta Srivastava served as Chief Editor, Indian J. Sugarcane Technology (Association of Sugarcane Technologists of India)
- Dr. Sangeeta Srivastava served as Member, Consulting Editors of SugarTech Journal (Springer Verlag)
- Dr. Sangeeta Srivastava served as Editor of Archives of Phytopathology and Plant Protection (Francis and Taylor)
- Dr. Sangeeta Srivastava served as Sectional Editor – Section V (Cell and Molecular Biology; Cytogenetics and Plant Breeding), JIBS (Journal of Indian Botanical Society)
- Dr. Sangeeta Srivastava served as Consulting Editor of Journal of Environmental Biology
- Dr. Sangeeta Srivastava served as Editorial Board member of Indian J. of Fundamental and Applied Life Sciences Open Access Online journal ISSN: 2231– 6345
- Dr. Sangeeta Srivastava served as Advisory board member (2021-22) of Agrica- International Journal of Plant Science Researches.
- Dr. S.N. Sushil acted as Editor, Journal of Eco-Friendly Agriculture.
- Dr. C.K. Gupta acted as Member, Editorial Board, Range Management and Agroforestry
- Dr. M. Swapna served as Editor of Sugar Tech, a peer reviewed journal related to sugar crops.

Reviewer

- All the Scientists of Division of Crop Production reviewed papers in several journals including Indian Journal of Agricultural Sciences. Sugar Tech, Agriculture, Ecosystem and Environment (Elsevier publication) and Indian Journal of Sugarcane Technology.

- Dr. Sangeeta Srivastava served as reviewer of research papers for the research journals *viz.*, PLOS One, BMC Genomics, 3Biotech (BITC), Sugar Tech, J. Env. Biol., JIBS
- Dr. Radha Jain served as reviewer for Plant Physiology Reports and Sugar Tech.
- Dr. Arun Baitha served as Reviewer for International Journal of Tropical Insect Sciences, Sugar Tech and Indian Journal of Entomology.
- Dr. M. Swapna served as Reviewer for peer reviewed journals *viz.*, Frontiers in Plant Sciences, Agricultural Systems, GCB-BioEnergy, Sugar Tech and Journal of Sugarcane Research.
- Dr. Sanjeev Kumar (Ag. Biotech.) served as Reviewer of international journals *viz.*, Journal of Plant Biochemistry and Biotechnology (Springer), Scientia Horticulturae (Elsevier), Physiology and Molecular Biology of Plants (Springer), Sugar Tech (Springer), South African Journal of Botany and Indian Journal of Biotechnology.
- Dr. Dinesh Singh examined book proposal entitled "Advance Mushroom Production" as expert reviewer and gave the expert comments to the Scientific Publishers (India), New Pali Road, Jodhpur.
- Dr. Dinesh Singh reviewed a Book on Commercial Entomology published by NIPA, New Delhi.
- Dr. Lalan Sharma acted as Reviewer for research papers for Journal of Environmental Biology.
- Dr. Shweta Singh acted as Reviewer of Indian Journal of Entomology, Archives of Phytopathology and Plant Protection, Indian Journal of Agricultural Sciences, Biocatalysis and Agricultural Biotechnology, Medicinal Plants, Journal of Packaging Technology and Research.
- Mr. Aalok Shiv served as Reviewer for international journals *viz.*, Journal of Plant Biochemistry and Biotechnology (Springer), Physiology and Molecular Biology of Plants (Springer), Plant Gene (Springer).

Member of RAC/IMC/QRT/IBSC

- Dr. A.K. Singh (Ag. Engg.) was nominated by ICAR as Member, Institute Management Committee of ICAR-IIOR, Hyderabad.
- Dr. A.K. Singh nominated by AKTU as Member, Board of Studies, Agricultural Engineering for another three years (2021 to 2024).
- Dr. Sangeeta Srivastava acted as Member Secretary of RAC of ICAR-IISR, Lucknow.
- Dr. Sangeeta Srivastava acted as Nodal Officer - EFC/SFC of Central Sector Scheme of ICAR "Improvement of Commercial Crops for Genetic Gains" (2021-22 to 2025-26)
- Dr. Sangeeta Srivastava acted as Member of Institute Management Committee (IMC) of ICAR-IISR, Lucknow
- Dr. Sangeeta Srivastava acted as Internal Expert, Institutional Bio-safety Committee (IBSC) of ICAR-IISR, Lucknow
- Dr. S.N. Sushil acted as Member, QRT of ICAR-NCIPM, New Delhi.
- Dr. S.N. Sushil acted as Member Secretary, QRT of ICAR-IISR, AICRP(S), KVK, Lucknow and Lakhimpur Kheri-II.
- Dr. P.K. Singh served as Expert Member for Research Advisory Committee of Research Programmes, UPCSR, Shahjahanpur.
- Dr. A.K. Sharma acted as nominated member of ITMC of ICAR-NBFGR, Lucknow.
- Dr. A.K. Sharma acted as nominated member of ITMC of ICAR-CISH, Lucknow.
- Dr. S.N. Sushil acted as Member, Institute Technology Management Committee, ICAR-NBAIR, Bengaluru.
- Dr. A.K. Sharma was nominated Member of RDC-Agricultural Economics of Mansarovar Global University, Bhopal
- Dr. Sanjeev Kumar (Biotech.) served as 'DBT Nominated Expert' for Institute Biosafety Committee of ICAR-IIPR, Kanpur for the period March 2020 to March 2023 and of ICAR-CISH for the period Dec. 2020 to Dec. 2023.

Member of Selection/Assessment Committee

- Dr. Sangeeta Srivastava acted as Expert in Selection Committee of Assistant Professor and Promotion from 9000 AGP to 10000 AGP under CAS for Genetics and Plant Breeding at Banda University of Agriculture and Technology (BUAT), Banda on 1st April, 2021.
- Dr. Sangeeta Srivastava acted as Member, Screening Committee for promotion and assessment of Scientists from 'D' to 'E' and from 'C' to 'D' at Birbal Sahni Institute of Palaeo Sciences (BSIP), Lucknow on November 22, 2021.
- Dr. Dinesh Singh served as External Expert Member of a Selection Committee for the selection of Junior Research Fellow, Division of Plant Pathology, UP Council of Sugarcane Research, Shahjahanpur, UP on February 10, 2021.
- Dr. Dinesh Singh served as External Expert Member of the Promotion Committee for Scientific Assistant Grade-II to Senior Scientific Assistant Grade-I of Division of Plant Pathology, UP Council

of Sugarcane Research, Shahjahanpur, UP on March 08, 2021.

- Dr. Dinesh Singh served as nominated Member (Governor Nominee) as Head of the Department for the selection of Assistant Professor and promotion from 9000 AGP to 10000 AGP under CAS for Plant Pathology Department, Banda University of Agriculture and Technology, Banda on March 22, 2021.

Chairman/Co-Chairman/Rapporteur

- Dr. S.N. Sushil acted as Chairman, Crop Protection Session in National Group Meeting of AICRP on Forage Crops organized in hybrid mode at ICAR-IGFRI, Jhansi on September 20, 2021
- Dr. Dilip Kumar acted as Chairman of technical session of *Rajya Gur Mahotsav* 2021 held at Lucknow.
- Dr. C.K. Gupta Co-chaired Young Scientist Session of NCPP-2021 at ICAR-NIASM, Baramati, Pune on December 10, 2021.
- Dr. Chandra Gupta was appointed as Co-Chairman of Technical Session-I: Water management in sugarcane on April 11, 2021 in the International Seminar 2021 (Virtual on-line): Agricultural Sustainability for Doubling Income in Changing Climate Scenario and Market Challenges during Covid-19 (ASDICCSMC-2020) on April 10-11, 2021 at University of Allahabad, Prayagraj.
- Dr. Y.E. Thorat acted as a Rapporteur in the Session-V (oral presentation) in the online National Seminar organized by Nematological Society of India (NSI), New Delhi on October 29-30, 2021.

Examinership

- Dr. Rajesh Kumar acted as Assistant Supervisor for Combined online examination of NET-2021, ARS-2021 (Preliminary) and STO (T-6) of Agricultural Scientist Recruitment Board (ASRB), New Delhi conducted during August 23-27, 2021 at ICAR-Indian Institute of Sugarcane Research, Lucknow.
- Dr. P.K. Singh served as Observer for Examinations conducted by ASRB and ICAR (IARI).
- Dr. P.K. Singh served as Examiner for Ph.D. and M.Sc. (Ag.) Thesis *viva-voce* of various Universities.
- Dr. Sangeeta Srivastava acted as Paper setter of M.Sc. Agriculture Semester 1 examination of 2021 of Lucknow University.
- Dr. A. Baitha served as examiner for practical examination of B.Sc. (H) Agriculture, in the Department of Agriculture at Integral University, Lucknow for the subject "Pests of crops and stored grain and their management" on December 20-21, 2021.
- Dr. A. Baitha evaluated M.Sc. (Ag.) thesis entitled "Studies on succession and management of major insect pests of rice" Department of Entomology, Birsa Agricultural University (BAU), Kanke, Ranchi (Jharkhand) on December 21, 2021.
- Dr. A. Baitha served as question paper setter for Integrated Pest Management of Crop Pests for B.Sc. (Ag), of Lucknow University on December 31, 2021.
- Dr. Dinesh Singh served as examiner for *viva voce* for preliminary examination of a Ph.D. Plant Pathology student of G.B. Pant University of Agriculture and Technology, Pantnagar on September 30, 2021.
- Dr. Dinesh Singh served as examiner for thesis and *viva-voce* examination of a M. Sc. Plant Pathology student of S.V. Patel University of Agriculture and Technology, Meerut on October 13, 2021.
- Dr. Dinesh Singh served as examiner for *viva voce* preliminary examination of two Ph.D. Plant Pathology students on September 20, 2021.
- Dr. Dinesh Singh served as examiner for thesis and *viva-voce* examination of six students of M.Sc. Plant Pathology of Acharya Narendra Deva University of Agriculture and Technology, Ayodhya on September 08, 2021.
- Dr. Dinesh Singh served as external examiner for online practical examination B.Sc. (Hons.) Agriculture II year/III Semester course Fundamental of Plant Pathology (AG 217) on February 5-6, 2021.
- Dr. A.K. Sah conducted *viva voce* exam of a Ph.D. student of BHU, Varanasi on July 14, 2021.
- Dr. A.K. Sah evaluated Ph.D. thesis of a student of CSAUA&T, Kanpur.
- Dr. Chandramani Raj served as external examiner at Faculty of Agricultural Science and Technology, Integral University, Lucknow.
- Dr. Shweta Singh served as external examiner at Faculty of Agricultural Science and Technology, Integral University, Lucknow.
- Dr. Sanjeev Kumar (Agri. Biotech.) served as External Examiner of Practical, B.Sc. (Ag.) and M.Sc. (Ag.) students of Integral University, Lucknow on March 15-16, 2021.

- Dr. Sanjeev Kumar (Agri. Biotech.) served as External Examiner of *viva voce* of a Ph.D. Thesis of a student of IESD, BHU, Varanasi on September 18, 2021.
- Dr. Sanjeev Kumar (Agri. Biotech.) served as External Examiner of Thesis *viva voce* of three M.Sc. (GPB) students of Institute of Agricultural Sciences, BHU, Varanasi on October 12, 2021.
- Mr. Aalok Shiv served as External Examiner of Practical, B.Sc. (Ag.) and MSc. (Ag.) students of Integral University, Lucknow on July 10, 2021.
- Mr. Aalok Shiv served as External Examiner of Thesis *viva voce* of M.Sc. (Plant Biotechnology) student at Banaras Hindu University, Varanasi.

Ph.D./M.Sc./B.Tech. thesis award to students

- Dr. Sangeeta Srivastava acted as Supervisor for dissertation of 04 post-graduate students as a part of their M.Sc. (Biotechnology) course at Amity University, Lucknow.
- Dr. Sangeeta Srivastava acted as Supervisor of dissertation of a B. Tech. Biotechnology student of SHUATS, Prayagraj.
- Dr. Dilip Kumar (Ag. Engg.) acted as Co-Advisor for the Thesis work of two M.Tech students of IGKV, Raipur.
- Dr. Deeksha Joshi served as co guide for a Ph.D. student, Ms. Monica Upadhyay registered at Maharaj Agrasen University, Baddi, Solan (H.P). Thesis titled "Characterization of *Trichoderma* spp. from sugarcane agro-ecosystem and their antagonistic effects against wilt and smut diseases of sugarcane" was submitted in October 2021.
- Dr. M. Swapna was selected as an event organizer for a proposed two-month training programme for Post-Graduate students under the *Vritika* Scheme of DST-SERB.
- Dr. M. Swapna acted as supervisor for thesis research work of a post-graduate student as a part of his M.Sc. course on Genetics and Plant Breeding at Bundelkhand University, Jhansi.
- Dr. D.N. Borase was recognized as a research co-guide/member for the M.Sc. (Agril. Microbiology) Programme of the Department of Plant Pathology and Agril. Microbiology, MPKV, Rahuri.
- Dr. Y.E. Thorat was recognized as a research co-guide/member for the M.Sc. (Agril. Entomology) Programme of the Department of Agricultural Entomology, MPKV, Rahuri.

Radio Talk

- Dr. Dinesh Singh delivered a radio talk on the topic "Disease management in sugarcane" on June 15, 2021.
- Dr. Dinesh Singh delivered a radio talk on the topic "Disease management in sugarcane with special reference to red rot" on July 20, 2021.

Others recognitions

- Dr. Sangeeta Srivastava served as Member, Organizing Committee of International *Sangoshthi* in Hindi on "*Atmnirbhar Bharat: Local Ke Liye Vocal*" held at IISR, Lucknow on March 16-17, 2021.
- Dr. Sangeeta Srivastava acted as Member, Scientific Advisory Committee at KVK, Lakhimpur Kheri.
- Dr. Sangeeta Srivastava was inducted as Associate member of The Asian Association of Sugarcane Technologists on 09 November, 2021.
- Dr. S.N. Singh was honoured by the Home Minister, Govt. of Madhya Pradesh at Datia (MP) for carrying out sugarcane development work in Narsinghpur district of Madhya Pradesh on March 19, 2021.
- Dr. T.K. Srivasatava 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. M. Swapna was nominated as a candidate by ICAR, New Delhi and attended an interview for selection of sugarcane breeding expert for a two-year deputation to SRI, Fiji conducted by MEA, New Delhi.
- Dr. D.N. Borase acted as Member Secretary of the "Project Monitoring Committee" for implementation of the RKVY Project constituted by Director Quality Control, Commissionerate of Agriculture, Govt. of Maharashtra.
- Dr. A.K. Sah was nominated Nodal Officer of IISR in Task Force Committee for Agro-Climatic Zones of Uttar Pradesh.
- Dr. A.K. Sah was nominated Nodal Officer in PMFME scheme of Govt. of Uttar Pradesh.
- Dr. A.K. Sah was nominated in a Committee constituted by Govt. of Uttar Pradesh for promoting Tourism in Sugar Industry.
- Dr. A.K. Sah was nominated by Vice Chancellor, CSAUA&T, Kanpur in Panel of Experts for promotion under CAS.

Hindi Award

- Dr. Radha Jain received First prize for "V*arsh bhar me kiye gaye Hindi karya ki samiksha*" during *Hindi Pakhwada* 2021, ICAR-IISR , Lucknow.
- Dr. Sangeeta Srivastava received Third Prize for *Varsh bhar mein Hindi mein karya* (*Vaigyanik varg*) during *Hindi Pakhwada* of ICAR-IISR, Lucknow, held in September 2021.
- Dr. Sangeeta Srivastava received Consolation Prize for *Ikshu lekh* during *Hindi Pakhwada* of ICAR-IISR, Lucknow, held in September 2021.
- Dr. Lalan Sharma received award in *Ikshu Mein Prakashit Lekh Hetu Pratiyogita* at ICAR-IISR, Lucknow during September 14-30, 2021.
- Dr. A. Baitha received prize for publishing popular article in *Ikshu* during *Hindi Pakhwada* on September 29, 2021.
- Dr A.K. Mall awarded Second Prize for *Varsh Bhar mein Hindi mein Karya* during *Hindi Pakhwada* held in September 2021.
- Dr. A.K. Mall awarded Consolation Prize for *Ikshu Lekh* during *Hindi Pakhwada* held in September 2021.
- Mr. Brahm Prakash received First Prize in Unicode Typing, Second Prize in Essay Writing , Powerpoint Presentation and *Varsh Bhar Mein Kiye Gaye Hindi Kaarya Ki Sameeksha* Competitions during *Hindi Pakhwada*-2021.
- Dr. Santeshwari awarded Consolation Prize for *Varsh Bhar mein* Hindi *mein Karya* during *Hindi Pakhwada* held in September 2021.
- Dr. Mukund Kumar awarded first prize in *Essay Competition*; consolation prize in *Varsh bhar mein hindi karya ki sameeksha; Ikshu Lekh*; third prize in *prastutikaran competition* during *Hindi Pakhwada* on September 14-30, 2021.
- Dr. Varucha Misra awarded first prize in *Varsh bhar mein hindi karya ki sameeksha* during *Hindi Pakhwada* on September 14-30, 2021.

Institute Committee

- Dr. Rajesh Kumar was chairman of committee for organizing National Science Day on February 28, 2021 at ICAR-Indian Institute of Sugarcane Research, Lucknow.
- Dr. Rajesh Kumar was chairman of committee for organizing World Water Day on March 22, 2021 at ICAR-Indian Institute of Sugarcane Research, Lucknow.
- Dr. Rajesh Kumar was member of core committee for organizing Group Meeting of All India Coordinated Research Project on Sugarcane during October 21-22, 2021 at ICAR-Indian Institute of Sugarcane Research, Lucknow.
- Dr. Rajesh Kumar was Chairman of Virtual Platform Committee for organizing Group Meeting of All India Coordinated Research Project on Sugarcane during October 21-22, 2021 at ICAR-Indian Institute of Sugarcane Research, Lucknow.
- Dr. Rajesh Kumar was Chairman of Virtual Platform Committee for organizing XXVII Meeting of Research Advisory Committee of ICAR-IISR, Lucknow during November 26-27, 2021 at ICAR-Indian Institute of Sugarcane Research, Lucknow.
- Dr. Rajesh Kumar was Chairman of Virtual Platform Committee for organizing visit of Quinquennial Review Team (QRT) of ICAR-IISR, Lucknow during December 17-18, 2021 at ICAR-Indian Institute of Sugarcane Research, Lucknow.
- Dr. Sangeeta Srivastava served as Chairman-Human Resource Development Committee of ICAR-IISR, Lucknow.
- Dr. Sangeeta Srivastava served as Chairman- EFC Plan Committee of ICAR-IISR, Lucknow.
- Dr. Sangeeta Srivastava served as Chairman, Germplasm Evaluation Committee of IISR, Lucknow
- Dr. Sangeeta Srivastava served as Presiding Officer, Internal Complaints Committee of ICAR-IISR, Lucknow.
- Dr. Sangeeta Srivastava served as Member, Agriculture Technology Foresight Committee, (ATFC) of ICAR-IISR, Lucknow.
- Dr. Sangeeta Srivastava served as Member, Award Committee for various institutional awards on Foundation Day 16 February, 2021.

Invited as key speaker in scientific meetings

- Dr. Sangeeta Srivastava delivered a lecture on "*Efficiency at Workplace*" for Capacity building training under HRD during March 04-06, 2021.
- Dr. Sangeeta Srivastava delivered a lecture on "Prevention of Sexual Harassment at workplace" in the training programme on Establishment Matters for LDC and UDC of ICAR held at IISR, Lucknow from November 15-20, 2021.
- Dr. Radha Jain delivered lecture as Invited speaker on need and utility of harvesting to crushing management, Dec. 30, 2021 at IISR, Lucknow.

CHAPTER 16

Publications

Research Papers

Babu SR, Singh D, Yadav SS, Rathore R Raj, Avasthe R, Yadav SK, Das Anup, Yadav V, Yadav B, Shekhawat K, Upadhyay PK, Yadav DK and Singh VK. 2021. Nanofertilizers for agricultural and environmental sustainability. *Chemosphere*, Available online 29 December 2021, https://doi.org/10.1016/j.chemosphere.2021.133451.

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Bhandari HR, Srivastava Kartikeya, Tripathi MK, Chaudhary Babita, Biswas S, and Shreya. 2021. Environment × combining ability interaction for quality traits in tomato (*Solanum lycopersicum* L.). *International Journal of Bio-resource and Stress Management* **12**(5):455-462.

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CHAPTER 17

Technical Programme (2021)

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, Sanjeev Kumar and N.K.K. Rathod 01/95-LT)
B 1.8	Defining ideotypes in sugarcane for moisture deficit conditions (A.K. Mall, Sangeeta Srivastava and S.P. Singh; 01/17-LT)
B 2.13	Development of sugarcane varieties for sub-tropics (Sanjeev Kumar, P.K. Singh, T.K. Srivastava, Manisha Saini, Aalok Shiv and N.K.K. Rathod; 10/03-LT)
B 2.15	Developing sugarbeet varieties for Indian agro-climates (A.D. Pathak, A.K. Mall, Arun Baitha, Sangeeta Srivastava, Aalok Shiv, Manisha Saini, N.K.K. Rathod, Mona Nagargade and V.P. Singh; 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, C.K. Gupta, Sangeeta Srivastava, Aalok Shiv and N.K.K. Rathod; 10/18-09/28)
B 3.19	Mapping of loci linked to sugar content in sugarcane (M. Swapna, and Manisha Saini; 12/09-03/22)
B 3.21	Production of disease free and genetically pure seed cane through tissue culture techniques (Sanjeev Kumar; 11/13-LT)
B 3.22	Development of *in vitro* conservation protocol using slow-growth tissue culture techniques in sugarcane (Sanjeev Kumar (Biotech.); 03/15-03/22)
B 3.23	Profiling and prediction of small RNA transcriptomes in sugarcane inoculated with red rot pathogen (Sangeeta Srivastava, A.D. Pathak and Dinesh Singh, 10/15-10/22)
B 3.24	Investigation of differentially expressing sugarcane proteins during red rot infection in susceptible and tolerant cultivars (Ranjit Singh Gujjar, Deeksha Joshi and Sangeeta Srivastava; 10/20- 09/25)
B 3.25	Population improvement and development of genetic stocks for high sugar accumulation potential (Swapna M, Sanjeev Kumar (Plant Breeding), Sanjeev Kumar (Biotech) and V. Srinivasa (SBI, Coimbatore); 10/20 – 09/25)
AICRP on Sugarcane	
B 1.1	Evaluation of early maturing sugarcane clones of North West Zone (Sanjeev Kumar, P.K. Singh, Aalok Shiv and N.K.K. Rathod; 02/09-LT)
B 1.2	Evaluation of mid-late sugarcane clones of North West Zone (Sanjeev Kumar, P.K. Singh, Aalok Shiv and N.K.K. Rathod; 02/09-LT)
B 1.3	Evaluation of sugarcane clones under Zonal Varietal Trials for North Central and Eastern Zone (A.K. Mall, A.D. Pathak, Aalok Shiv and N.K.K. Rathod; 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; 03/15-09/26, 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]

Project Code	Title of the project
DST WOS-A	Investigating sucrose accumulation through RNA-seq bulked segregant analysis in sugarcane (PI: Nandita Banerji, 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, S.P. Singh, V.P. Jaiswal. T.K. Srivastava, A.P. Dwivedi; 06/17– 09/22)
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, A.K. Singh (Engg.), S.K. Shukla, V.P. Jaiswal, Dinesh Singh and S.N. Sushil; 06/17 –09/22)
A 2.38	Soil quality assessment under different sugarcane growing systems (S.R. Singh, T.K. Srivastava, R.R. Verma, Pushpa Singh, S.N. Singh, A.K. Singh, R.S. Dohare; 03/15-03/21)
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, Rajendra Gupta and A.K. Sharma; 03/17-08/22)
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 and V.K. Singh: 4/19-03/24)
A 2.41	Management of bio-resources for enhancing sugarcane productivity and soil health (A.P. Dwivedi, M.K. Tripathi, V.K. Singh, K.K. Singh and S.R. Singh: 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 2.44	Enhancing water productivity of sugarcane production system by regulating irrigation regimes and field moisture management (T.K. Srivastava, Rajendra Gupta, R.R. Verma and Pushpa Singh; 10/20- 09/25)
A 2.45	Assessing nutritional management approach for enhancing cane and sugar productivity of multiple ratooning initiated under variable dates (S.N. Singh; 10/19-09/21)
A 3.24	Enhancing system productivity and profitability of wide row planted autumn sugarcane through intercropping of high value crops (C. Gupta, V.P. Singh, S.K. Shukla, M.K. Tripathi, S.R. Singh, S.P. Singh, A.K. Singh (AE): 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)
AET 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 – 03/22)

Project Code	Title of the project
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; 02/16-LT)
Inter Institutional collaborative Project	
ICAR-IISR, Lucknow and Institute of Nano Science & Technology, Mohali	Nano-urea for improved nitrogen use efficiency in sugarcane (Mona Nagargade, Deeksha Joshi, Dilip Kumar, Amaresh Chandra, V.P. Jaiswal and S.R. Singh; 08/19-07/24)
ICAR-IISR, Lucknow and ICAR-CAZRI, Jodhpur	Efficacy and evaluation of potassic organo mineral fertilizer (OMF) in sugarcane crop (V.P. Jaiswal, 09/20-09/22)
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, 2014-2021)
AS 71	Carbon sequestration assessment in sugarcane based cropping system (V.P. Jaiswal, S.K. Shukla, V.P. Singh; 2016-2021)
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)
AS 75	Precision nutrient management through rescheduling time of application for widely spaced sugarcane plant-ratoon system (V.P. Jaiswal, 2019-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	
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	
BASF India Ltd., Navi Mumbai	Evaluation of bio efficacy and phytotoxicity of pre-emergent application of two herbicide products BAS 781 02 H and BAS 822 01 H against weeds in sugarcane and its effect on succeeding crop (S.K. Yadav, M.K. Dwivedi, S.K. Shukla, A.D. Pathak, D.N. Borase and Y.E. Thorat; 04/18-03/21, Budget: ₹ 15.0 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: ₹ 33.0 lakh)
United Phosphorus Ltd., Mumbai	Bio-efficacy and 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	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)
United Phosphorus Ltd., Mumbai	Evaluation of PIX 10042 76.75% WG against important weeds of sugarcane and its effect on soil micro flora, succeeding crop and yield (A.P. Dwivedi and A.D. Pathak; 11/19-12/21; Budget: ₹ 15.0 lakh)

Project Code	Title of the project
Narmada Biochem Limited	Assessing efficacy of Narmada PROM (Phosphorus rich organic manure) as an organic source of P on soil quality and productivity of cane and sugar in Indian sub-tropics (S.N. Singh, A.D. Pathak, V.K. Singh and R.K. Singh; 03/19-07/22 Budget: ₹ 10.0 lakh)
Agrions India Private Limited	Assessing efficacy of Agrions AMF (Arbuscular Mycorrhizal Fungi) on the productivity of sugarcane and sugar in sub-tropical India tropics (S.N. Singh, A.D. Pathak, V.K. Singh and R.K. Singh; 05/19-04/22, Budget: ₹ 10.0 lakh)
BASF India Pvt. Ltd. Mumbai	Bio-efficacy and phytotoxicity evaluation of 'BAS 433 11 H' against broad leaved weeds and sedges in sugarcane and its effect on succeeding crop (V.P. Jaiswal, S.K. Yadav, S.K. Shukla, Lalan Sharma and Mona Nagargade; 04/21 – 03/22 for Lucknow and S.K. Yadav, D.N. Borase and Y.E. Throat for Pravaranagar; 09/20 – 09/21, Budget: ₹ 20.0 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, M.K. Tripathi; 09/19-12/22; Budget : ₹ 15.0 lakh)
Zydex Ind. Pvt. Ltd. Vadodara (Gujarat)	Effect of Zytonic M and microbial consortia on sustaining soil health and sugarcane yield in subtropical India (M.K. Tripathi, Mona Nagargade, S.K. Shukla and V.P. Jaiswal; 04/20 – 03/22; Budget: ₹ 6.0 lakh)
Acadian Seaplants Ltd., Goregaon West, Mumbai (MS)	Evaluation of the effect of SoliGro GR on growth and yield of sugarcane (S.R. Singh, M.K. Tripathi, A.P. Dwivedi and A.D. Pathak; 2019-2021, Budget: ₹ 10.00 lakh)
ISK Biosciences India Private Limited, Delhi	Bio-efficacy evaluation of SL 160 25% WG herbicide against weed complex in sugarcane (V.P. Singh, K.K. Singh, Dileep Kumar and A.D. Pathak; 2020-2022, Budget: ₹ 12.0 lakh)
Division of Crop Protection	
EM 01	Survey and surveillance of insect pests and diseases of sugarcane in sub-tropical India (Sharmila Roy and all the Scientists of Crop Protection Division; Duration: Long Term)
M 5.10	Management of Yellow Leaf Disease (YLD) of sugarcane through thermotherapy (Dinesh Singh, 05/15-04/22)
M 17	Evaluation/screening of sugarcane germplasm against red rot and smut (Dinesh Singh, 1992-93-LT)
M 15.6	Enhancing efficacy of *Trichoderma* based red rot management system (Deeksha Joshi and Pushpa Singh, 04/12-03/21)
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)
M 15.8	Isolation, identification and pathogencity of wilt pathogen in sugarcane (Sanjay K. Goswami, Deeksha Joshi, Dinesh Singh and S.P. Singh, 10/20 -09/25)
M 15.9	Characterization of yellow leaf disease pathogens of sugarcane in sub-tropical India (Shweta Singh, Chandramani Raj, Arun Baitha, Sangeeta Srivastava, R.S. Gujjar and S. Vijayanand Roy; 10/21-09/28)
M 15.10	Artificial intelligence based detection of disease and insect-pests in sugarcane (Chandramani Raj, S.N. Sushil, Arun Baitha, S.S. Hasan, Shweta Singh and Rajesh U. Modi; 10/21-09/26)
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 howard*i (A. Baitha, M.R. Singh, A.K. Jaiswal, S. Roy and S.N. Sushil; 10/18-09/22)

Project Code	Title of the project
Ento 2.1.2	Developing arthropods-based soil health indicator for subtropical sugarcane ecosystem (Sharmila Roy, A.K. Jaiswal, D. Joshi, S.R. Singh and Yogesh E. Thorat: 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 (S.K. Goswami and Shweta Singh)
PP 17	Evaluation of zonal varieties against red rot, smut and wilt (S.K. Goswami, Shweta Singh and Chandramani Raj)
PP 22	Survey of sugarcane diseases naturally occurring in the area on important varieties (S.K. Goswami and Chandramani Raj)
Entomology	
E 4.1	Evaluation of varieties/genotypes for their reaction against major insect pests (A. Baitha and Sharmila Roy)
E 28	Survey and surveillance of sugarcane insect pests (Sharmila Roy and Arun Baitha)
E. 30	Monitoring of insect pests and bio-agents in sugarcane agro-ecosystem (A. Baitha and Sharmila Roy)
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	
United Phosphorus Ltd., Mumbai	Bio-efficacy and phytotoxicity of fungicide "SAAF Gr (Carbendazim 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)
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; 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; 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)

Project Code	Title of the project
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, 2013-2023)
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 Radha 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 - 08/21)
AE 1.52	Development and evaluation of tractor operated multipurpose tool frame with attachments for sugarcane (Sukhbir Singh and A.K. Singh, 10/15- 09/21)
AE 1.23	Development of cane node planter (A.K. Singh and S.N. Singh; 09/16 -08/23)
AE 1.24	Ergonomic evaluation of tools and equipment for drudgery reduction in sugarcane cultivation (Sukhbir Singh, A.K. Singh and M.K. Singh; 10/20 -09/23)
AE 1.25	Development of e-powered multipurpose equipment adapted to controlled traffic farming for sugarcane (M.K. Singh, A.K. Singh and Sukhbir Singh; 04/21-03/26)
AE 1.81	Development of sugarcane trash management machinery (M.K. Singh, A.K. Singh and R.D. Singh: 09/18-08/23)
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, 11/16-10/22)
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 – 11/21)
AE 7.6.2	Development of a jaggery furnace with efficiency boosting device (S.I. Anwar, 04/12-03/21)
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)
IISR-SBI/2019/01	Inter-Institutional Collaborative Project on testing and evaluation of selected IISR sugarcane machinery under tropical conditions (A.K. Singh (IISR) and T. Arumuganathan (SBI) and T. Senthil Kumar (CIAE RS); 02/19-01/22)
AICRP on Farm Implements and Machinery (FIM)	
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/2021/01	Prototype feasibility testing of automatic potato-cum-sugarcane trench planter (A.K. Singh, Sukhbir Singh and M.K. Singh, 09/21 – 09/24)
FIM/IISR/PFT/2021/02	Prototype feasibility testing of pedal operated paddy thresher (Sukhbir Singh and A.K. Singh, 09/21-09/24)
FIM/IISR/FLD/2017/02	IISR tractor operated modified sugarcane cutter planter (A.K. Singh, Sukhbir Singh and M.K. Singh, 03/21 – 03/24)
FIM/IISR/FLD/2017/01	IISR tractor operated two row disc type ratoon management device (A.K. Singh and Sukhbir Singh, 03/21 -03/24)
FIM/IISR/FLD/2017/04	IISR tractor operated deep furrow sugarcane cutter planter-cum-raised bed multicrop seeder (A.K. Singh, M.K. Singh and Sukhbir Singh, 03/20-03/23)
FIM/IISR/FLD/2020/01	IISR tractor operated multipurpose interculturing equipment (Sukhbir Singh and A.K. Singh, 01/20 -12/23)

Project Code	Title of the project
AICRP on Post-harvest Engineering Technology (PHET)	
PHT/IISR/01	Comparative quality assessment of the jaggery prepared by sugarcane cultivated through chemical pesticide (Clorantraniliprole) and herbal formulation (Dilip Kumar, V.P. Jaiswal and Arun Baitha, 09/21-08/23)
PHT/IISR/02	Evaluation and transfer of sugarcane based technologies/process developed by other centres (Dilip Kumar and M.K. Singh, 04/21-03/23)
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, 12/15-03/21, 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 – 01/22; 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 – 03/22, Budget : ₹ 220 lakh)
DST funded project under Women Scientist Scheme B (WoS-B)	Modified atmosphere packaging of sugarcane juice in closed system (PI: Priyanka Singh, Mentor: Dilip Kumar, Co-Mentor: Pushpa Singh, 09/19-09/22; Budget: ₹ 35.0 lakh)
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 – 10/22)
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; 01/17-12/22)
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; 03/15-03/22)
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 – 03/22)
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 and A.D. Pathak, 10/16-09/22)
AES 4.21	Efficiency of designs in sugarcane field experiments (RCBD *vs* Alpha design) (Rajesh Kumar, Rajendra 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)

Project Code	Title of the project
AES 4.23	International sugar trade and export opportunities for Indian sweeteners (L.S. Gangwar, A.K. Sharma, S.S. Hasan and A.K Sah; 10/20-09/23)
AES 4.24	A study of IoT and artificial intelligence (AI) enablers in sugarcane farming system (S.S Hasan. 10/20-09/23)
IISR Biological Control Centre, Pravaranagar	
EM 01	Survey and surveillance of insect-pests and diseases of sugarcane in sub-tropical area (Sharmila Roy, HoD and all Scientists of IISR Biological Control Centre, Pravaranagar; Duration: LT)
BCC 1.1	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)
BCC 1.2	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)
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, Sharmila Roy, Deeksha Joshi, Arun Baitha, D.N. Borase and Y.E. Thorat; Budget : ₹ 5.0 crore; Duration: 04/17-04/22)
Contract Research Project	
BASF	Evaluation of bio efficacy 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; Duration: 04/18-03/21, Budget : ₹ 15.0 lakh)
United Phosphorus Ltd., Mumbai	Bio-efficacy and phytotoxicity evaluation of UPST 119 against early shoot borer, white grubs and termites infesting termites (D.N. Borase, S.N. Sushil, Arun Baitha, Y.E. Thorat, 02/21-01/23, Budget: ₹ 15.0 lakh)
United Phosphorus Ltd., Mumbai	Bio-efficacy and phytotoxicity evaluation of GPH 1521 against broad-leaved weeds and sedges in sugarcane and its effect on succeeding crop (D.N. Borase, S.K. Yadav, Dileep Kumar, Y.E. Thorat, 03/21-02/23, Budget: ₹ 18.0 lakh)
VSI, Pune	Bio-efficacy testing of entomopathogenic fungi as a biopesticide against white grubs and whitefly in sugarcane (Y.E. Thorat, D.N. Borase, S.N. Sushil, 02/21-01/23, Budget: ₹ 5.0 lakh)
Bayer Crop Science Ltd., Mumbai	Bio efficacy and phytotoxicity evaluation of Solomon 300 OD against black bug infestations in sugarcane (Y.E. Thorat, D.N. Borase, S.N. Sushil, 10/21-09/23, Budget: ₹ 13.0 lakh)
BASF India Ltd., Navi Mumbai	Bio efficacy and Phytotoxicity evaluation of BAS 43311H against broad-leaved weeds and sedges in sugarcane and its effect on succeeding crop (Pravaranagar Centre), (D.N. Borase, Y.E. Thorat; 01/21-08/23, Budget: ₹ 20.0 lakh)
United Phosphorus Ltd., Mumbai	Bio efficacy and phytotoxicity evaluation of GPI 1820 against early shoot borer, white grub and termite infesting sugarcane (D.N. Borase, Arun Baitha, S.N. Sushil, Y.E. Thorat, 01/21-08/23, Budget: ₹ 13.0 lakh)

CHAPTER 18

Review, Monitoring and Evaluation

Research Advisory Committee Meeting

The XXVII Meeting of Research Advisory Committee of ICAR-Indian Institute of Sugarcane Research, Lucknow was held on November 26-27, 2021 in hybrid mode under the Chairmanship of Dr. S.K. Datta, Ex. Deputy Director General (CS), ICAR, New Delhi. Dr. N. Vijayan Nair, Ex. Director, ICAR-SBI, Coimbatore; Dr. S.V. Sarode, Ex. Director of Research, Dr. PDKV, Akola; Dr. A.K. Vasisht, Ex. ADG (PIM), ICAR, Krishi Bhawan, New Delhi; Dr. J.P. Mishra, OSD (PPP) and ADG (IR), ICAR, Krishi Bhawan, New Delhi; Dr. R.K. Singh, Assistant Director General (CC), ICAR, Krishi Bhawan, New Delhi; Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow; Mr. Sudhir Kumar Singh Siddhu, District Barabanki (IMC Member) and Dr. Sangeeta Srivastava, PS and Head (I/c), Division of Crop Improvement, ICAR-IISR, Lucknow and Member Secretary were the other Members of RAC who were physically present in the meeting. Dr. Indra Mani, Head, Division of Agricultural Engineering, ICAR-IARI, New Delhi and Sri R.L. Tamak, CEO and Executive Director, DCM Shriram, New Delhi attended the RAC Meeting in virtual mode: All the Heads of Divisions/In Charges of Sections, In-Charges of RC, Motipur, BCC, Pravaranagar and Sugar Beet Breeding Outpost, Mukteswar as well as all the Scientists of the Institute also participated in the meeting as special invitees. Dr. A.D. Pathak, Director, IISR made a presentation on the Research Highlights of ICAR-IISR, Lucknow and the major activities undertaken by the Institute during 2020-21. The Action Taken Report on the recommendations of XXVI RAC Meeting held on December 15, 2020 was presented by Dr. Sangeeta Srivastava, Member Secretary. After discussion, the RAC adopted the ATR on the recommendations of XXVI RAC. All the Heads of the Divisions/In-Charges, Sections made the presentations on research activities and achievements of the respective Divisions/Sections during the past one year. Following major recommendations emerged during the meeting:

1. There is an urgent need to identify/develop a suitable replacement for the ruling variety Co 0238 in view of the severe red rot incidence. The conventional approaches for recombination breeding should focus on developing varieties that are at par with Co 0238 incorporating red rot resistance. Use of biotechnological strategies like genome editing also need to be considered in this regard. The Institute should also make efforts to prolong the field life of this variety with seed management and plant protection methods. Since the genome sequence of *C. falcatum* (red rot pathogen) along with the draft genome sequence of sugarcane are available, the information from these studies, along with the other molecular approaches need to be integrated in to the on going research projects.

Interactions with experts in the field of genome editing should be organized through workshop and other meetings and collaborative programmes need to be formulated.

2. Sugarcane genetic improvement and varietal development programme should take care of following points:

- Resistant sources within basic germplasm may be used to develop superior red rot resistant varieties. Evaluation of ISH and IGH clones may be taken up to identify genetic stocks adapted to sub-tropical conditions.

- Considering the new energy policy, efforts should be made to develop varieties/technologies suited for ethanol production from juice and agro-biomass (2 G ethanol).
- Germplasm and hybrid populations may be evaluated for identifying potential clones capable of winter sprouting and growth.
- Drone based high throughput phenotyping and root system studies may be included in the project on "Deciphering ideotypes for moisture deficit conditions".

3. Long-term epidemiological studies are an important continuous component in view of climate change and, disease & insectpests need continuous surveillance. Such studies need to be reorganized for human resources management to have multiple discipline knowledge with at least one scientist of all the three layers (Principal Scientist, Senior Scientist and Scientist). Bioagents such as nematodes and pheromones are potential tools of insect-pests management. The collaborative work/projects on pheromones may be explored with the Institutes like NCL, Pune and ICT, Hyderabad. The presence of parasites/predators in the nature need to be documented along with the insect-pests in order to understand the balance between the different components.

- The IISR Biological Control Centre, Pravaranagar should develop a comprehensive integrated pest management module for woolly aphids, white grub and *Pyrilla* to demonstrate at a few places in order to enhance the visibility of Institute.

5. In the physiological programmes, the mechanism behind the output of the effect may also attempted to be studied *e.g.* the catalytic agents/mechanisms (enzymes/metabolism) for higher root density due to salinity and/or other treatments in sugarcane. It would be interesting to see the genomic and physiological manifestations leading to biomass development in sugarcane.

6. Cutting edge technologies like sensor-based tools, automation, artificial intelligence, drone technology *etc.*, should be used for crop management and protection. The integration of AI, machine learning, drone technology and start-up ecosystem is required in sugarcane cultivation.

7. Efforts may be made to strengthen the linkages for making pan India presence of IISR sugarcane machineries and jaggery technologies. All India level licensing of agricultural machinery is required by signing of MoAs with reputed agricultural machinery manufacturers having good manufacturing infrastructure.

8. Economic impact of IISR developed technologies should be clearly mentioned and highlighted in order to help policy makers get an idea about the economic impact. Economics of bioethanol *vs.* sugar production may be worked out to help shape government's policies. Role of second-generation ethanol *vis-à-vis* Govt. policies on ethanol production must be studied.

9. The Institute should also focus on developing a village as 'Model Village' by selecting villages where sugarcane intensity is more than 70%. The help of Agricultural Economists and other Social Scientists should be taken in selection of the villages. The project should be in a multi-institutional mode. The help of ICAR-NIAP (National Institute of Agricultural Economics & Policy Research), New Delhi; ICAR-IASRI, New Delhi and Environmental Science Division, ICAR-IARI, New Delhi may also be sought.

10. A workshop on sugar beet should be conducted at Mukteswar, inviting seed companies handling with sugar beet, progressive farmers, industry people, experts and economists in order to develop a model to popularize sugar beet cultivation in India.

Institute Research Council Meeting

The Institute Research Council (IRC) meeting of the ICAR-Indian Institute of Sugarcane Research (IISR), Lucknow was held in online mode under the Chairmanship of Dr. A.D. Pathak, Director of the Institute during July 26-31 and September 23-24, 2021 to review and discuss the on-going research projects on sugarcane in the Institute. Sixty-two scientists and one technical officer of the Institute participated and discussed the research findings of 73 ongoing-Institute research projects, and the technical programme for the next year. Following eight new research project proposals were submitted by the scientists and presented in IRC which were approved after through discussion:

1. Investigation of differentially expressing

sugarcane proteins during red rot infection in susceptible and tolerant cultivars

2. Population improvement and development of genetic stocks for high sugar accumulation potential
3. Enhancing water productivity of sugarcane production system by regulating irrigation regimes and field moisture management
4. Isolation, identification and pathogenicity of wilt pathogen in sugarcane
5. Ergonomic evaluation of tools and equipment for drudgery reduction in sugarcane cultivation
6. Development of e-powered multipurpose equipment adapted to controlled traffic farming for sugarcane
7. International sugar trade and export opportunities for Indian sweeteners
8. A study of IOT and artificial intelligence (AI) enablers in sugarcane farming system

Meeting of Quinquennial Review Team

Meeting of Quinquennial Review Team to review the research work of the ICAR-Indian Institute of Sugarcane Research, Lucknow; AICRP on Sugarcane, KVK, Lucknow and KVK, Lakhimpur Kheri –II for the period 2016-2020 was held at ICAR-IISR, Lucknow on December 17-18, 2021 under the chairmanship of Dr. Y.S. Nerker, Ex. Vice Chancellor, MPKV, Rahuri; Dr. U.K. Behara, Dean, College of Agriculture, CAU, Umiam, Meghalaya; Dr. M.N. Premchandran, Ex. Head, Division of Crop Improvement, ICAR-Sugarcane Breeding Institute, Coimbatore; Dr. G.T. Gujjar, Ex. Head, Division of Entomology, ICAR-IARI, New Delhi; Dr. Surendra Singh, Ex. Project Coordinator (FIM), ICAR-CIAE, Bhopal and Dr. K. Anand Reddy, Director (HRD) and PC, PGDM (ABM), MANAGE, Hyderabad were other QRT members present in the meeting. At the outset, Dr. A.D. Pathak, Director of the Institute welcomed all the Members. The ATR of previous QRT was presented by Dr. S.N. Sushil, Member Secretary. All the Heads of the Division and Incharge, Sections presented the salient achievements of their Divisions/Sections for the period 2016-2020.

Institute Management Committee Meeting

Forty ninth meeting of the Institute Management Committee (IMC) was held under the chairmanship of Dr. A.D. Pathak, Director,ICAR-IISR, Lucknow on July 12, 2021. Progress of R & D efforts was reviewed and various administrative matters were discussed in the meeting.

Institute Biosafety Committee Meeting

The Institute Biosafety Committee (IBSC) Meeting was held on December 29, 2021 (Virtual Mode) under the Chairmanship of Dr. A.D. Pathak, Director of the institute. The meeting was attended by Dr. Manish Mishra (DBT nominee; Principal Scientist, ICAR-CISH, Lucknow), External Experts, Dr. Mahender Singh (Principal Scientist, ICAR-NBFGR, Lucknow) and Dr. Kusum Yadav (Associate Professor, University of Lucknow), Internal Experts, Dr. Sangeeta Srivastava, Dr. Amaresh Chandra, Dr. R.S. Gujjar, and Dr. Sanjeev Kumar (Member Secretary). The Chairman, Dr. A.D. Pathak stressed the need of taking utmost care while handling equipment, hazardous chemicals, *etc.* The Member Secretary, Dr. Sanjeev Kumar presented the ATR and briefed about different projects being undertaken by PIs. Members discussed various steps taken by different laboratories of the Institute in the area of biosafety. It was informed that the new project staff/ trainees are made aware about safety aspects in the laboratory, and are encouraged to visit the websites providing information on Regulatory Compliance by IBSC and ICAR Bio-safety Portal. Dr. Manish Mishra, DBT nominee opined that since no research project related to recombinant DNA technology is undertaken at present, there was no need to assess bio-safe containment facility. The present disposal system of laboratory waste, buffers, plasticware, agarose gel, *etc.*, was discussed at length.

CHAPTER 19

Participation in Seminars/Webinars/Symposia/Conferences etc.

Name	Seminars/Webinar/ Symposium/Conference	Venue/Organizer	Date
Drs. S.N. Singh and Arun Baitha	Review Meeting pertaining to Release of RKVY Funds with the Commissioner (Agric.), Govt. of Maharashtra, Pune	Office of Commissioner (Agric.), Govt. of Maharashtra, Pune	January 4, 2021
All Scientists of the Institute, Mr. Brahm Prakash, Dr. G.K. Singh and Mr. Adil Zubair	Zonal Breeders and Plant Protection Scientists' Meet of AICRP on Sugarcane	ICAR-IISR, Lucknow	January 24, 2021
Dr. A.K. Sah	Round-table Discussion on Drone: GIS Application for Agriculture	PHD Chamber of Commerce and Industry, New Delhi	January 27, 2021
Dr. Shweta Singh	ISMPP 41st Annual Conference and National e-Symposium on Innovative Approaches in Plant Health Management	Indian Society of Mycology and Plant Pathology	January 28-30, 2021
All the Scientists of Division of Crop Production	Webinar on "Herbicide Resistance in India: Problems and Management"	ISWS and ICAR- DWR, Jabalpur	January 29, 2021
All the Scientists of Division of Crop Production	Webinar on "Philosophy and Spiritual Concept of Swami Vivekananda: It's Relevance to Present Day Society and Science"	ISWS and ICAR- DWR, Jabalpur	January 31, 2021
All the staff of the Institute	71st Foundation Day Celebration Programme of ICAR-IISR, Lucknow	ICAR-IISR, Lucknow	February 16, 2022
Dr. S.K. Shukla	Brain Storming Session on Role of Potassium Salt of Active Phosphorus (PSAP) in Sugarcane Productivity	NSI, Kanpur	February 18, 2021
Dr. Kamta Prasad	Webinar on "Sensitizing Extension Professionals for Successful Livestock Farming Models to Develop *Aatmnirbhar Kisan*"	KVK, ICAR-IVRI, Izatnagar	February 19-20, 2021
Dr. Deepak Rai	23rd Agricultural Scientists and Farmers Congress	Bioved Research Institute of Agri. Technology & Science, Prayagraj	February 21, 2021
All the Scientists of Division of Crop Production and Dr. S.K. Yadav	Webinar on "Agriculture Research through Knowledge Discovery"	EBSCO Information Services, South Asia	February 23, 2021
Drs. A.D. Pathak, Barsati Lal and Kamta Prasad	Webinar on "Smart Agriculture and Budget Implementation"	Ministry of Agriculture & Farmers Welfare, GOI, New Delhi	February 24, 2021
All the Scientists of Division of Crop Production	Webinar on "Weeds of National Importance"	ISWS and ICAR- DWR, Jabalpur	February 25, 2021
Dr. A.K. Sah	Conference on "Building Uttar Pradesh for New India"	CII, Uttar Pradesh State Unit, Lucknow	February 26, 2021
Drs. S.K. Shukla, Radha Jain, S.N. Singh, V.K. Singh, S.R. Singh, S.N. Sushil and Mona Nagargade	Scientific Advisory Committee Meeting of KVK-II, Lakhimpur Kheri	KVK-II, Lakhimpur Kheri	March 6, 2021
Drs. A.D. Pathak A.K. Sah, Barsati Lal and Kamta Prasad	*MEETHA*: National Conference on Sugar & Health-Myth & Realities	NSI, Kanpur	March 8, 2021
Drs. Barsati Lal and Kamta Prasad	Webinar on Restructuring Agricultural Research to Fast Track Impact: An Integrative System Perspective	ICAR, New Delhi	March 10, 2021
Drs. Amaresh Chandra, Radha Jain, Chandan Kumar Gupta and Rajeev Kumar	International Plant Physiology Virtual Symposium (IPPVS) 2021 on Physiological Interventions for Climate Smart Agriculture	ICAR-SBI, Coimbatore	March 11-12, 2021
Dr. A.D. Pathak, all the Scientists and technical personnel	National Webinar *on "Atmanirbhar Bharat: Vocal for Local"*	ICAR-IISR, Lucknow	March 16-17, 2021

Name	Seminars/Webinar/ Symposium/Conference	Venue/Organizer	Date
Drs. A.D. Pathak, A.K. Sharma, L.S. Gangwar and Mr. Brahm Prakash	34th National Conference on Agricultural Marketing	Dr. BBAU, Lucknow	March 16-18, 2021
All the Scientists of Division of Crop Production and Dr. Lalan Sharma	Webinar on Translating Physiological Tools to Augment Crop Breeding	ICAR-IIWHR, Karnal	March 17-19, 2021
Drs. M.R. Singh S.N. Singh and S.I., Anwar	Demonstration of IISR Quality Jaggery Making Technology	Datia (M.P.)	March 19, 2021
Dr. A.D. Pathak and all the Scientists of the Institute	Lecture on "Valuing Water" by Dr. Susama Sudhishri, Principal Scientist, WTC, ICAR-IARI, New Delhi	ICAR-IARI, New Delhi	March 22, 2021
Scientists of Division of Crop Production	Webinar on "Quarantined Weed and Weed Risk Analysis"	ISWS and ICAR- DWR, Jabalpur	March 23, 2021
Drs. Dinesh Singh, Deeksha Joshi, S.K. Goswami, Chandramani Raj and Shweta Singh	National e-conference "Plant Health and Food Security: Challenges and Opportunities"	IPS, New Delhi	March 25-27, 2021
Dr. P.K. Singh	International Seminar on PPV&FR Act	PPV &FRA, New Delhi	April 8, 2021
Director and all the Scientists of the Institute	Brain Storming Meeting on Management of Red Rot in Sugarcane	ICAR-IISR, Lucknow	April 12, 2021
Dr. P.K. Singh	24th Annual Breeder Seed Review Meeting and 36th AGM of AICRP-NSP and 16th ARM of ICAR Seed Project	ICAR-IISS, Mau	April 21-22, 2021
Er. V.A. Blessy	Global Virtual Summit on Management of Degraded Lands for Restoring Our Earth	ISCO	April 22, 2021
Dr. A.D. Pathak, all the Scientists, CAO, FAO and Mr. Brahm Prakash	Meeting to Discuss Covid-19 and its Management at the Institute	ICAR-IISR. Lucknow	April 22, 2021
Dr. A.D. Pathak and all the Scientists of the Institute	Webinar on Earth Day	ICAR-IISR. Lucknow	April 22, 2021
Dr. A.D. Pathak, all the Scientists, SAO & FAO	Meeting to Discuss Technical and Administrative Matters	ICAR-IISR. Lucknow	April 29, 2021
Scientists of Division of Crop Production	Webinar on "Alien Invasive Weeds in India"	ISWS and ICAR- DWR, Jabalpur	April 30, 2021
Dr. A.D. Pathak, all the Scientists, SAO & FAO	Meeting to Discuss Technical and Administrative Matters	ICAR-IISR, Lucknow	May 4, 2021
Dr. A.K. Sah	Sugar Industry- Potential for Providing Bioenergy & Oxygen	NSI, Kanpur	May 10, 2021
Scientists of Division of Crop Production	Webinar on "Aquatic Weeds: Problems and Their Management for Improving Water Productivity"	ISWS and ICAR- DWR, Jabalpur	May 29, 2021
All the staff of the Institute	Meeting for Taking 'No Tobacco Pledge'	ICAR-IISR, Lucknow	May 31, 2021
Dr. A.D. Pathak and all the Scientists	Webinar on Sustainable Soil Management	KVK, ICAR-IISR. Lucknow	May 31, 2021
Dr. A.D. Pathak and all the Scientists	Webinar on Sustainable Soil Management	KVK-II, ICAR-IISR. Lakhimpur Kheri	May 31, 2021
Dr. A.D. Pathak and all the Scientists	Webinar on Clean Milk Production	KVK, ICAR-IISR. Lucknow	June 1, 2021
Dr. A.D. Pathak and all the Scientists	Webinar on Clean Milk Production	KVK-II, ICAR-IISR. Manjhra Farm, Lakhimpur Kheri	June 1, 2021
Dr. A.D. Pathak, all the Scientists, SAO and FAO	Meeting to Discuss Technical and Administrative Matters	ICAR-IISR, Lucknow	June 2, 2021
Drs. A.D. Pathak and A.K. Sah	Demonstration on Drone Spray	Loni, Hardoi	June 2, 2021
Drs. A.D. Pathak and Sangeeta Srivastava	Online Meeting on EFC Presentation of Sub-scheme : Improvement of Commercial Crops for Genetic Gain" of Crop Science SMD	ICAR, New Delhi	June 3, 2021
Drs. A.D. Pathak and Sangeeta Srivastava	Online Meeting on EFC Presentation and Preparation for Continuation	ICAR, New Delhi	June 4, 2021

Name	Seminars/Webinar/ Symposium/Conference	Venue/Organizer	Date
Dr. A.D. Pathak and all the scientists	Online *Kisan Goshthi* on the World Environment Day	KVK, ICAR-IISR, Lucknow	June 5, 2021
Dr. Kamta Prasad	Webinar on "Ecosystem Restoration for Sustainable Food Production and Human Health"	ICAR-IISS, Bhopal	June 05, 2021
Dr. A.D. Pathak and all Scientists	Webinar on "Food Safety: How Relevant is for India"	ICAR-IISR. Lucknow	June 7, 2021
Dr. A K. Sah	Webinar on "Safe Food Today for a Healthy Tomorrow"	PHD Chamber	June 07, 2021
Dr. Kamta Prasad	Webinar on "Showcasing AI Start-ups Solving Problem of Farming System and Future Opportunities",	ICAR – NIVEDI, Bengaluru	June 11, 2021
Dr. Kamta Prasad	International Webinar on "Innovations and Entrepreneurship Development in Agriculture"	ICAR-NDRI, Karnal	June 17, 2021
Dr. A.K. Sah	Webinar on "Global Report on Food Crises 2021"	IFPRI, New Delhi	June 17, 2021
Scientists of Division of Crop Production and Dr. S.K. Yadav	International Webinar on Innovation and Entrepreneurship Development in Agriculture	Southern Regional Station of ICAR-NDRI, Karnal	June 17, 2021
Dr. A.K. Mall	Maharana Pratap Memorial Lecture 2021 on "Increasing Farmers Income: Way Forward"	MPUAT, Udaipur	June 18, 2021
Dr. A.D. Pathak, all the Scientists, SAO and FAO	Meeting to Discuss Technical and Administrative Matters	ICAR-IISR, Lucknow	June 18, 2021
Drs. A.D. Pathak, S.K. Shukla, Sangeeta Srivastava, C. Gupta, M. Swapna, Dinesh Singh, Deeksha Joshi, Chandramani Raj, S.K. Yadav, Lalan Sharma S.K. Goswami, Shweta Singh, Om Prakash, Brahm Prakash and Kamini Singh	International Conference on Sugarcane Research: Sugarcane for Sugar and Beyond (CaneCon 2021)	SSRD, SBI, Coimbatore and TNAU, Coimbatore	June 19-22, 2021
Er. V.A. Blessy	National Workshop on Water Budgeting: An Approach For Sustainable Water Resources Management in Rajasthan	AICRP on Irrigation Water Management	June 21, 2021
Scientists of Division of Crop Production	Webinar on "Role of Weed Biology in Improving Weed Management Strategies"	ISWS and ICAR- DWR, Jabalpur	June 22, 2021
Dr. Kamta Prasad	Webinar on "Role of Rural India in Sustainable Development"	ICAR-NDRI, Karnal	June 26, 2021
Dr. A.D. Pathak	Webinar on "How to Overcome Stress" by Gurudev Sri Sri Ravi Shankar	ICAR, New Delhi	June 28, 2021
Dr. A.D. Pathak, all the Staff of the Institute	Lecture on *Rajbhasha Hindi Ke Vikas Mein Kathinaiyaan* by Dr. Pawan Agarwal, Lucknow University, Lucknow	ICAR-IISR. Lucknow	June 30, 2021
Drs. A.D. Pathak and Sangeeta Srivastava	Lecture of Dr. Rajeev K. Varshney, Research Programme Director, ICRISAT, Patancheru on the topic "Genomics and Breeding Innovations in Agriculture"	ICAR, New Delhi	July 6, 2021
Dr. A.K. Sah	Meeting on Sugarcane Developmental Programme	Directorate of Rice Development, Patna	July 12, 2021
Dr. S.K. Goswami	International-e conference on Harnessing microbes in agriculture: An opportunity for organic farming	Narayan Institute of Agricultural Sciences, GNSU, Rohtas,	July 15-16, 2021
Drs. A.D. Pathak and all the Scientists of the Institute	National Webinar on "Water Productivity for Profitable Agriculture"	ICAR-IISR, Lucknow	July 16, 2021
Dr. A.D. Pathak, all the Scientists, SAO and FAO	Meeting to Discuss Technical and Administrative Matters	ICAR-IISR. Lucknow	July 19, 2021
Drs. Sangeeta Srivastava and M.K. Singh	National Webinar on "Artificial Intelligence for Smart Agriculture"	ICAR-RCER, Patna	July 22, 2021
Dr. A.K. Mall	National Webinar on "Heat Wave: Impact on Agriculture"	SKNAU, Jobner	July 22, 2021
Dr. A.D. Pathak, all the Scientists of the Institute, Mr. Brahm Prakash, Dr. Anita Sawnani and Sh. Ashish Singh Yadav	Meeting of IRC of ICAR-IISR, Lucknow	ICAR-IISR, Lucknow	July 26-31, 2021

Name	Seminars/Webinar/ Symposium/Conference	Venue/Organizer	Date
Drs. Sangeeta Srivastava, Sukhbir Singh, Rajesh U. Modi, Om Prakash, Kamini Singh and Mr. Brahm Prakash	National Conference on Role of Agricultural Engineering in Economic Development and Self-Dependence during COVID-19 Situation	ICAR-CIAE, Bhopal	July 28-29, 2021
Dr. A.K. Mall	National Webinar on "Precision Techniques in Protected Cultivation"	MPUA&T, Udaipur	July 29, 2021
Dr. M.K. Singh	National Webinar on "Challenges of Intellectual Property Rights (IPR) for Innovations in Agricultural Machinery"	MPUA&T, Udaipur	August 06, 2021
Dr. M. Swapna	Webinar on "Agricultural Transformation for Nutritional Security"	ICAR-DCFR, Bhimtal	August 7, 2021
Dr. M. Swapna	Webinar on "Abiotic Stress Management in Agriculture"	CSAUA&T, Kanpur	August 10, 2021
Dr. A.K. Mall	Webinar on "Private Equity for Biological Research"	Society for Plant Research	August 10, 2021
Drs. S.R. Singh, V.K. Singh, A.P. Dwivedi, M.K. Tripathi, A.K. Sah, Sanjeev Kumar (Pl. Breeding), C.K. Gupta and Sukhbir Singh	Foundation Day of KVK, Lakhimpur Kheri-II	KVK, Lakhimpur Kheri-II	August 11, 2021
Dr. A.K. Sah	India @ 75: Government and Business Working Together for *Aatmanirbhar Bharat*	Confederation of Indian Industry	August 11-12, 2021
Dr. Kamta Prasad	National Webinar on "Integrated Farming System for Sustainable Livelihood and Nutritional Security"	ICAR- IIFSR, Meerut	August 12, 2021
Dr. A.D. Pathak and all the Scientists of the Institute	Webinar on "New Paradigms in Biological Control of Insect Pests and Diseases"	ICAR-IISR, Lucknow	August 16, 2021
Drs. M. Swapna, Chandramani Raj and Shweta Singh	Webinar on "Quarantine Procedures for National And International Exchange of Plant Materials"	ICAR-SBI RC, Kannur	August 16, 2021
Scientists of Division of Crop Production	Webinar on "The *Parthenium* Weed Problem and its Management at the Global Level"	ISWS and ICAR- DWR, Jabalpur	August 16, 2021
Dr. S.N. Singh	Meeting with the Hon'ble Agriculture Minister, Govt. of Maharashtra	Ministry of Agriculture, Mantralaya, Mumbai	August 18, 2021
Dr. M.K. Singh	International Webinar on "Emerging Technologies in the Agricultural Engineering for Food Safety & Security"	Dr. NTR College of Agricultural Engineering, Bapatla	August 25-27, 2021
Dr. M. Swapna	Webinar on "Entrepreneurship Opportunities in Nutrition for Farmers"	ICAR-SBI, Coimbatore	August 26, 2021
All the Scientists of Crop Production Division and Dr. S.K. Yadav	National Seminar on "Rice-fallow Management in Eastern India"	ICAR-RCER, Patna	August 26, 2021
Drs. S.K. Shukla and Pushpa Singh	RAC Meeting of UPCSR, Shahjahanpur	ICAR-RCER, Patna	August 27-28, 2021
Drs. M. Swapna and Kamta Prasad	Webinar on 'Economizing Water Signature in Agriculture: Sugarcane –A Case Study'	ICAR-SBI, Coimbatore	August 31, 2021
Dr. A.D. Pathak	46th Foundation Lecture by Dr. Krisha Ella, CEO, Bharat Biotech	ICAR-NAARM, Hyderabad	September 1, 2021
Dr. Kamta Prasad	Webinar on "Medicinal Plants Cultivation for Doubling Farmers Income"	ICAR-DMAPR, Anand	September 09, 2021
Dr. Sangeeta Srivastava	Online Meeting with STI Ecosystem for *Aatmnirbhar Bharat*: STI, Institutions in Uttar Pradesh	CST-UP, Lucknow	September 13, 2021
Drs. A.D. Pathak, A.K. Sah and Mr. Abhishek Kumar Singh	Award Function organized by *Rajbhasha Vibhag*, Ministry of Home, Govt. of India	*Vigyan Bhawan*, New Delhi	September 14, 2021
Dr. A.D. Pathak and all the Staff of the Institute	Lecture on *Bharteey Samaj: Vividhta, Anekta Evam Ekatmakta* by Dr, Saurabh Malviya, Expert, Samagr Shiksha, Directorate of Basic Education, UP, Lucknow	ICAR-IISR, Lucknow	September 17, 2021
Drs. A.D. Pathak, A.K. Dubey and all SMSs of KVK, Lucknow	*Poshan Vaatika Mahaabhiyaan*	KVK, ICAR-IISR, Lucknow	September 17, 2021

Name	Seminars/Webinar/ Symposium/Conference	Venue/Organizer	Date
Drs. M. Swapna, A.K. Sah and Kamta Prasad	Webinar on "Sugarcane-based Entrepreneurship Development: A Profitable Venture"	ICAR-SBI, Coimbatore	September 18, 2021
Dr. Sanjeev Kumar (Agril. Biotechnology)	The ISO/IEC: 17025 Assessor Training (Level 2) organized by NABI	Hotel Double Tree, Gurugram	September 22-26, 2021
Dr. A.D. Pathak, all the Scientists of the Institute, Mr. Brahm Prakash, Dr. Anita Sawnani and Mr. Ashish Singh Yadav	Institute Research Council Meeting of ICAR-IISR, Lucknow	ICAR-IISR, Lucknow	September 23-24, 2021
Dr. A.D. Pathak and all the Staff of the Institute	Lecture on "*Hindi Ke Prayog Kee Vyapakta"* by Dr. Amita of U.P. *Hindi Sansthan*	ICAR-IISR, Lucknow	September 25, 2021
All the Scientists of Division of Crop Production	Webinar on " Harvesting of Weed Seeds: A Novel Preventive Way of Weed Management"	ISWS and ICAR- DWR, Jabalpur	September 28, 2021
Dr. A.D. Pathak and all the Staff of the Institute	Campaign on Climate Resilient Agriculture inaugurated by Hon'ble Prime Minister	ICAR, New Delhi	September 28, 2021
Scientists of Division of Crop Production, Drs. M.K. Singh S.K. Yadav, Kamta Prasad and Lalan Sharma	International Webinar on "Alternate Cropping Systems for Climate Change and Resource Conservation"	ICAR-IIFSR, Meerut	September 29 – October 1, 2021
Dr. A.D. Pathak and all the staff of the Institute	*Swachchh Bharat Abhiyaan*	ICAR-IISR, Lucknow	October 2, 2021
Drs. Sangeeta Srivastava, S.N. Sushil, A.K. Sah and M. Swapna	The 79th Annual Convention of Sugar Technologists Association of India (STAI) and Sugar Expo	NSI, Kanpur	October 4-5, 2021
Dr. Niranjan Lal	ISEE National Seminar on Transforming Indian Agriculture through Pleuritie and Innovative Extension Approaches for Self Reliant India	BHU, Varanasi	October 4-6, 2021
Scientists of Division of Crop Production, Dr. S..K. Yadav and Er. V.A. Blessy	National Conference on "Integrated Farming Systems: A Tool for Enhancing Income and Nutritional Security"	ICAR-RCER, Patna	October 5-7, 2021
Dr. Kamta Prasad	Webinar on "Science, Technology and Innovation for Transforming Agriculture in India"	ICAR, New Delhi	October 12, 2021
Dr. Kamta Prasad	Webinar on "Gender Empowerment for Rural Women"	ICAR-NRC for Grapes, Pune	October 13, 2021
Dr. Sukhbir Singh	Webinar on "Develop Road-Map up to 2030 to Take Forward Agricultural Mechanization in India"	NRFMT&TI, Hisar	October 18, 2021
Er. V.A. Blessy	Global Symposium on Salt Affected Soils	FAO	October 20-22, 2021
Dr. P.K. Singh	66th DSTA Annual Convention	DSTA	October 21, 2021
Drs. A.D. Pathak, Sangeeta Srivastava, T.K. Srivastava and S.N. Sushil	Varietal Identification Committee of AICRP on Sugarcane	ICAR-IISR, Lucknow	October 21, 2021
Dr. A.D. Pathak and all the Scientists of the Institute	Annual Group Meeting of AICRP on Sugarcane	ICAR-IISR. Lucknow	October 21-22, 2021
Dr. A.K. Sah, Mr. Brahm Prakash, Dr. Om Prakash	*Kisan Goshthi* and *Swachchhta Abhiyaan*	Village Manpur, Biswan, Sitapur	October 28, 2021
Dr. A.D. Pathak and all the Scientists of the Institute	Online Interaction Meeting of Secretary, DARE and DG, ICAR with all the ICAR Scientists	ICAR, New Delhi	October 28, 2021
All the Scientists of Division of Crop Production	Webinar on "Weed Flora and their Management in Rice and Wheat Cropping Systems"	ISWS and ICAR- DWR, Jabalpur	October 29, 2021
Dr. A.D. Pathak and all the staff of the Institute	Pledge on the Occasion of Vigilance Awareness Week	ICAR-IISR, Lucknow	October 30, 2021
Dr. Niranjan Lal	*Virat Kukkut Mela*	ICAR-CARI, Izatnagar	November 2, 2021
Drs. L.S. Gangwar, A.K. Sah, S.K. Goswami and Om Prakash	XV Agriculture Science Congress and Expo-2021 on Energy and Agriculture Challenges in 21st Century	BHU, Varanasi	November 13-16, 2021
Dr. M. Swapna	Webinar on 'Enzymes for Second Generation Ethanol: Addressing the Challenges"	ICAR-SBI, Coimbatore	November 18, 2021
Dr. Sanjay Kumar Pandey	Workshop of CFLD on Pulses and Oilseeds	BUAT, Banda	November 22-23, 2021

Name	Seminars/Webinar/ Symposium/Conference	Venue/Organizer	Date
Dr. R.D. Singh	55th Annual Convention and International Symposium of Indian Society of Agricultural Engineering	Gyan Bhawan, Gandhi Maidan, Patna	November 23-25, 2021
Drs. S.K. Shukla, V.P. Singh, S.N. Singh, C. Gupta, V.P. Jaiswal, S.K. Yadav, Dileep Kumar and Mona Nagargade	5th International Agronomy Congress	PJTSAU, Hyderabad	November 23-27, 2021
Dr. A.D. Pathak, all Scientists of the Institute and Sh. Brahm Prakash	Meeting of Research Advisory Committee of the Institute	ICAR-IISR. Lucknow	November 26-27, 2021
Er. V.A. Blessy	Meeting on Management of Surplus-Deficit Dichotomy in North Eastern Agriculture to Enhance the Productivity	NIRDPR-NER, Guwahati with ICAR-RC for NE Region, Meghalaya	November 30, 2021
Drs. A.D. Pathak, Sangeeta Srivastava and L.S. Gangwar	4th Webinar on "Implementation and Use of Agricultural Research Management System (ARMS)"	ICAR-IASRI, New Delhi	December 2, 2021
Dr. Sangeeta Srivastava	NASI Symposium on "Interface between Biological and Physical Sciences towards *Aatmnirbhar Bharat*"	National Academy of Sciences, Prayagraj	December 4-6, 2021
Dr. A.D. Pathak and all the Scientists of the Institute	Programme on World Soil Day	KVK, ICAR-IISR, Lucknow	December 5, 2021
Dr. A.D. Pathak and all Scientists of the Institute	Programme on World Soil Day	KVK-II, Manjhara Farm, Lakhimpur Kheri	December 5, 2021
Dr. Sangeeta Srivastava	Talk on "CRISPR/CAS-enabled Crop Precision Breeding and Disease diagnostics" by Prof. Yinong Yang, Penn Stat. University, USA	ICAR-NRRI, Cuttack	December 7, 2021
Dr. M. Swapna	5th Annual Conference on "Nano for Agri-2021: Technology Readiness and Overcoming Regulatory Barriers to Implement Nanotechnology-Enabled Agriculture for Sustainable Future"	TERI, New Delhi	December 8-9, 2021
Dr. A.D. Pathak and all scientific & technical staff	Webinar on "Natural Farming (Zero Budget Natural Farming" addressed by Sh Narendra Modi, Hon'ble P.M. of India	ICAR, New Delhi	December 16, 2021
Dr. A.D. Pathak, all the Heads of the Divisions and I/c, Sections	Meeting of QRT of ICAR-IISR, Lucknow, AICRP on Sugarcane and KVKs of ICAR-IISR, Lucknow	ICAR-IISR. Lucknow	December 17-18, 2021
Dr. A.K. Sah	2nd National Conference on Transformation of Agricultural Extension- Strategies for Effective Reformation (TAESERE 2021)	S.V. Agricultural College (ANGRAU), Tirupati	December 22- 23, 2021
Drs. Barsati Lal, Om Prakash and Mr. Brahm Prakash	*Kisan Diwas* Celebration	Village Rebha Muradpur, Hardoi	December 23, 2021
Dr. A.D. Pathak and all the Scientific and technical staff	Webinar on "The Source, Generation Rate & Endpoint of Covid Plastic Waste" delivered by Dr. Chirashree Ghosh, Associate. Professor, University of Delhi, Delhi	ICAR-IISR, Lucknow	December 26, 2021
Dr. A.D. Pathak and all the staff of the Institute	*Swachchhta* Campaign led by Mrs. Sanyukta Bhatia, Hon'ble Mayor, Lucknow	ICAR-IISR, Lucknow	December 30, 2021

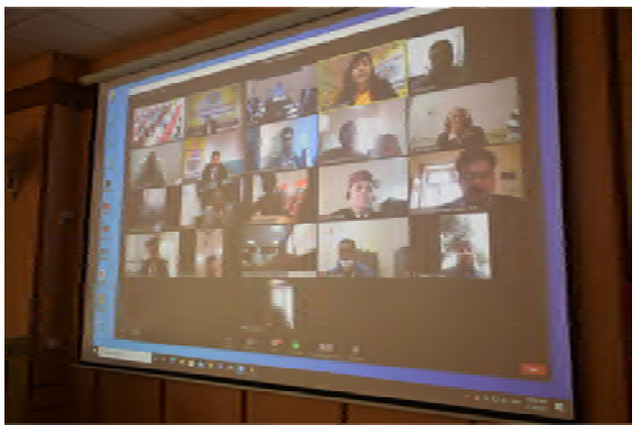
CHAPTER 20

Events Organized

Institute establishment ceremony

Foundation Day of the Institute celebrated

The 70th Foundation Day celebration of the IISR, Lucknow was celebrated with great fervour on February 16, 2021 in the Institute campus. Praising the immense contribution of Scientists of the Institute in sugarcane research, the Chief Guest at the Foundation Day celebration, Dr. Trilochan Mohapatra, Secretary, DARE, GoI and DG, ICAR urged the Scientists to reduce the water consumption of 2,000 litres of water in producing one kg of sugar to almost 50% by next five years. Dr. Mohapatra directed the Scientists to take the challenges of studying the effects of diseases, pests and productivity on sugarcane crop due to climate change, reducing the maturity period of sugarcane crop to less than 12 months and to enhance production of bioethenol for 20% blending in petrol. He urged the Scientists to prepare time-bound strategy to tackle these issues. He also appreciated the efforts of the Institute in increasing the sugarcane productivity in Uttar Pradesh from 60 to 80 t/ha, and sugar recovery from 9.50 to 11.40% and increasing the income of farmers in eight villages adopted under PPP mode from 1.8 to 2.0 times during the last three years.



Dr. TR Sharma, DDG (CS), ICAR expressed his concern over the increasing incidence of red rot disease in wonder variety Co 0238 occupying > 70% area in U.P. and urged the Scientists to develop its alternative as well as research on the diagnosis of red rot disease. Dr. Sharma emphasized on the development of sugarcane genotypes against abiotic and biotic stresses through biotechnological interventions and development of various value-added products related to sugar and sugar-based products.

Dr. A.D. Pathak, Director, IISR discussed the historical achievements of the Institute like MHAT, spaced transplanting techniques, cane node technology, seed priming by ethrel for quick and high germination, mechanized trench planting method, FIRB system for wheat cultivation with sugarcane, sugarcane based intercropping system, control of pests and diseases by bioagents, tractor operated sugarcane trench planter and deep furrow sugarcane cutter-planter. Dr. Pathak informed that four improved varieties of sugarcane have been developed by the Institute along with production and protection technology. On this occasion, Dr. Mahapatra also inaugurated a Technology Tower constructed to disseminate the major achievements, Conference Hall and a Mobile App *'Ikshu Kedar'*. Four publications of the Institute *viz.*, IISR at a Glance, Water Footprint in Sugarcane, Ethephon: Impact on Sugarcane Physiology and Sugar Productivity and *'Ikshu'* were also released. At the outset, Dr. R.K. Singh, ADG (Commercial Crops), ICAR, welcomed all the distinguished guests and all the participants in his address and appreciated the efforts of the Institute for record production of

sugarcane and sugar in U.P. The programme was conducted by Dr. Anita Sawnani. In the Award Distribution Ceremony organized on the occasion, Dr. Sushil Solomon, former VC, CSAUA&T, Kanpur and Dr. A.D. Pathak, Director awarded 14 officials of the Institute in various categories. The award for Best Scientist was presented to Dr. S.K. Shukla, Head, Division of Crop Production. The team of SWAPAM Lab of Crop Production Division was honoured as the Best Research Team for their remarkable contribution in the field of Microbial Consortia.

National Webinar on "Water Productivity for Profitable Agriculture"

A National Webinar on 'Water Productivity for Profitable Agriculture' was organized under the aegis of ICAR-Indian Institute of Sugarcane Research, Lucknow on 16th July, 2021 to discuss and deliver on the current scenario of water productivity in agriculture, water footprints of various crops and commodities, ways and means to raise the water use efficiency in sugarcane cultivation, impact of climate change, adaptation & mitigation measures. Dr. P.S. Brahmanand, Principal Scientist (Agronomy), ICAR-Indian Institute of Water Management, Bhubaneshwar and Dr. N. Subash, Principal Scientist (Agro-meteorology), ICAR-Indian Institute of Farming System Research, Meerut delivered lectures on water productivity and climate change, respectively. Dr. A.D. Pathak, Director, ICAR-IISR chaired the session and exhorted sugarcane researchers to explore the ways for maximizing water productivity in sugarcane production system. He also emphasised on conducting inter-institutional collaborative research to address the relevant issues. Participants from scientific institutions, sugarcane development personnel of sugar mills, State government officials and sugarcane growers participated in the webinar hosted by Dr. T.K. Srivastava, Principal Scientist (Agronomy), ICAR-IISR as Organizing Secretary. The webinar concluded with a formal vote of thanks by Dr Rajesh Kumar, In-charge, AKMU, ICAR-IISR, Lucknow.

National Conference on *"Aatmnirbhar Bharat: Local Ke Liye Vocal"*

A two-day National Conference on "*Aatmnirbhar Bharat: Local Ke Liye Vocal*" was organized at the Institute under the auspices of ICAR-IISR, Lucknow and Indian Council of Agricultural Research on March 16-17, 2021. The Chief Guest, Shri Hriday Narayan Dixit, Speaker, Vidhan Sabha, Uttar Pradesh told that self-reliant India is not opponent of globalisation, as it is strong believer of the concept of "*Vasudhaiv Kutumbkam*". Self-reliant India will not only be helpful in improving the prosperity of the country but being an integral part of the globe, it will certainly benefit the whole world. Citing the example of global popularity of *yoga,* Shri Dixit told that vocal for local will further lead to global from local. He suggested to speak our own language for protection of Indian culture and multidimensional development. The Guest of Honour, Prof. Surya Prasad Dixit, Ex. Head, Department of Hindi, University of Lucknow stressed the need of maximum use of Hindi which is a powerful and enriched language. Citing the various revolutions of various sectors of agriculture, Dr. A.K. Singh, DDG (Ag. Extension), ICAR stressed the need of rainbow revolution and sustainable agriculture preserving natural resources. He highlighted the importance of training for skill development of self-help groups, FPOs and migrant labourers for translating the concept of self-reliance India of Mahatma Gandhi into reality. Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow welcomed the guests, participants and gave a brief presentation on the history and salient achievements of the Institute in the field of sugarcane and sugar sector. Dr. A.K. Sah, Organizing Secretary gave a brief introduction about the theme of the Conference and discussed about 17 special talks to be delivered during four technical sessions.

Discussing the self reliance of India in sugarcane and sugar sectors, Dr. Sushil Solomon, Ex. VC, CSAUA&T, Kanpur expressed his satisfaction for economizing use of precisous foreign exchange by the blending of ethanol in petrol, produced from molasses -

a co-product during sugar manufacturing by the sugar mills. Expressing satisfaction on increase of about 100 lakh tonnes production of pulses during last ten years, Dr. N.P. Singh, Director, ICAR-IIPR, Kanpur presented the strategic plan for enhancing pulses production every year by 10 lakh tonnes. He also advocated for development of a strategic plan for oilseeds also. Dr. K.D. Joshi, ICAR-NBFGR, Lucknow highlighted about the development of enormous employment opportunity in fisheries conservation, fisheries based eco-tourism, fish feed along with value addition, net for catching fish and placing nets at the places of fish production. Discussing the contribution of horticultural crops in self-reliant India, Dr. Vishal Nath, Director, NRC on Litchi, Muzaffarpur stressed the need for being vocal for enhancing income of farmers of fruits and vegetables and increasing the popularity of vitamin and anti-oxidants enriched fruits and vegetables production. Dr. Anita Sawnani told that social empowerment of ladies is the only solution in the present scenario. At the end, Dr. M.K. Tripathi, Principal Scientist proposed the vote of thanks. More than 300 delegates participated in the Conference in online mode.

Hindi Pakhwara

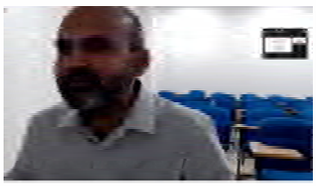
Hindi Pakhwara was organized at ICAR-IISR, Lucknow during September 14-30, 2021. Number of competitions like typing in Unicode, Circular Writing, Slogan writing, Debate, Review of Hindi work done during the last year, article writing competition for *Ikshu*, *Antakshari etc.*, were organized. A number of scientists, technical, administrative and supporting staff participated in various competitions with great zeal. On September 29, 2021, the winners of various competitions organized during *Hindi Pakhwara* were awarded. Dr. A.D. Pathak, Director, all Heads of Divisions, Sh. Saroj Kumar Singh, Chief Administrative Officer and Dr. A.K. Sah, Member Secretary *(Rajbhasha)* were present on the dias. The Certificates and Cash Prize for First, Second, Third and Consolation Prizes were distributed to 80 personnel representing various categories of the staff.

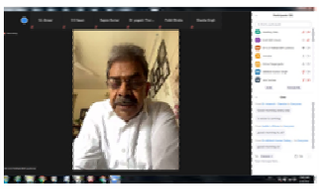
On this occasion, a presentation of journey of seven decades of IISR was made. During the fortnight, Dr. Saurabh Malviya, Directorate of Basic Education, Lucknow delivered a lecture on "*Bharteey Samaj: Vividhta, Anekta Evam Ekatmakta*". A Hindi Workshop was also organized during the fortnight. Mrs. Amrita Dubey, Editor, Uttar Pradesh *Hindi Sansthan* delivered a lecture on "*Hindi Vishay Ki Vyapakta*". A *Kavi Sammelan* was also organized in which popular poets *viz.*, Shri Ram Kishore Tiwari, Shri Sudeep Bhola, Shri Ashok Jhanjhati, Dr. Mansi Dwivedi, Shri Santosh Dixit, Shri Pankaj Prasoon and Dr. Sudhir Kumar Shukla recited their poems. More than 350 persons enjoyed the poems recited in *Kavi Sammelan.*

National Campaigns and Missions

National Science Day celebrated

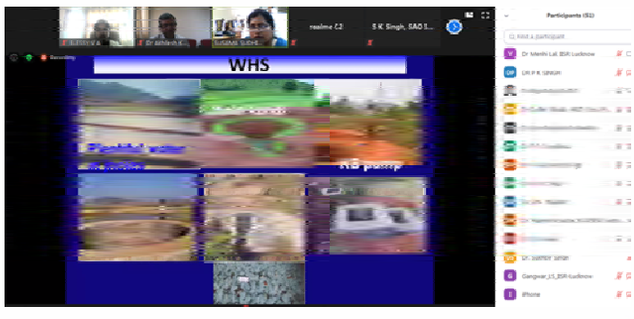
National Science Day was celebrated at the ICAR-IISR, Lucknow on February 28, 2021. This day commemorates the invention of the Raman Effect by the great Indian Physicist, Sir Chandrasekhar Venkata Raman. The theme of National Science Day 2021 was "Future of STI: Impact of education skills and work". On this occasion, Dr. P.S. Vijaya Kumar, Scientist-D, Institute of Nano Science and Technology, Mohali (Punjab) delivered a special talk on "Targeted farming: a dream come true with future". The programme was conducted by Dr. Mona Nagargade, Scientist, Division of Crop Production.





World Water Day celebrated

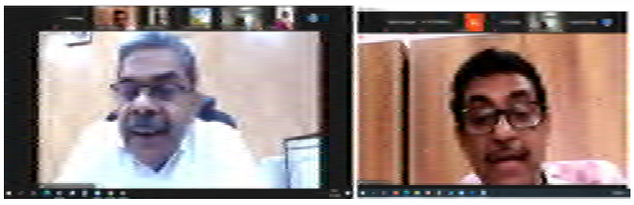
World Water Day was celebrated at the ICAR-IISR, Lucknow on March 22, 2021. To mark the occasion, a Webinar on Valuing Water was organized on Zoom platform. On this occasion, Dr. Susama Sudhisri, Principal Scientist, Water Technology Centre, ICAR-IARI, New Delhi delivered a lecture.



A *Kisan Goshthi* was also organized on this occasion by KVK, Lucknow which was attended by 55 farmers of Lucknow district.

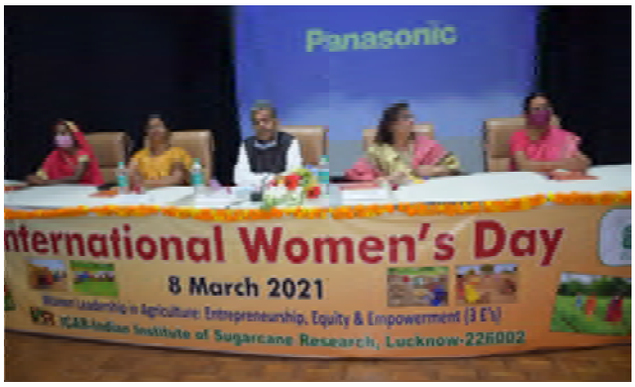
International Yoga Day celebrated

The ICAR-IISR, Lucknow celebrated the 7th International Day of Yoga on June 21, 2021. The theme for International Yoga Day 2021 was "Yoga for Well-being". On this occasion, a lecture was delivered by Dr. A.K. Sah, Incharge, Extension and Training, ICAR-IISR, Lucknow on "*Yoga Ka Itihaas Evam Labh*". Continuing the tradition of participating in a worldwide event on International Day of Yoga, the scientists and staff of the Institute celebrated the day by performing yoga at their homes with their families.



International Women's Day celebrated

The International Women's Day was observed at ICAR-IISR, Lucknow on March 8, 2021 with great fervour. The day is celebrated to recognise the social, economic, cultural and political achievements of women also marks a call to action for accelerating gender parity. On this occasion, Dr. A.D. Pathak, Director motivated all the women staff of the Institute for believing in themselves. Dr. Pathak added that women are seen as household workers. Traditionally Indian mindset treats women as a good mother or a good housewife and they don't even are provided many opportunities for career building. This is the sad reality of women's life. Women are getting empowered and strong by the passage of time but unfortunately, still, there is a need for social awareness. Dr. Pathak asked that being a part of this society, how somebody can discriminate them on the basis of gender? He informed that for all of these reasons, a global event is specially celebrated for reminding their position in society. Women's security and safety are one of the big global challenges. Dr. Sangeeta Srivastava and Dr. Radha Jain also expressed their views on Women's Leadership in Agriculture: Entrepreneurship, Equity & Empowerment (3 E's). It was indeed a noble day organized by the Institute which served the aim of empowering women which made them feel appreciated and valued.



Plantation Drive

A plantation drive was organized at the ICAR-IISR, Lucknow on July 7, 2021. The programme was

inaugurated by the plantation of a plant of *Rudraksh* by Dr. A.D. Pathak, Director of the Institute. On this occasion, highlighting the importance of plantation, Dr. Pathak urged all the officers and employees to plant few trees near their homes. During this plantation drive, more than 500 plants were planted in the Institute Campus by all the officers and staff.

Parthenium Awareness Week organized

ICAR-IISR, Lucknow along with both the KVKs located at Lucknow and Lakhimpur Kheri organized *Parthenium* awareness week during August 16-22, 2021. On this occasion, Dr. A.D. Pathak, Director, ICAR-IISR termed *Parthenium hysterophorus* (locally known as carrot weed, *gajar ghas* or congress grass) as the most problematic alien invasive weed which has spread

alarmingly in cropped, non-cropped, forest area and invaded millions of hectares of land throughout India. All the scientists and staff joined in the campaign and uprooted plants of *Parthenium* in and around Institute campus and farm.

Swachhata Pakhwada organized

Swachhta Pakhwada was organized at the Institute during December 16-31, 2021. On December 16, 2021, banners were displayed at all the gates of the Institute. *Swachhata* pledge was taken by all the staff members of the Institute.

On December 17, 2021, digitalization of office records was discussed in detail with all concerned officers. All the IISR Annual Reports have been digitalized. Several old photographs which were available were digitalized and kept in CD/DVD. The cleanliness drive of the office premises was initiated. Old and obsolete furniture and other junk material which was stored for a long period was auctioned and lifted from the Office. On December 18, 2022, cleanliness and sanitation drive in the village adopted under the *Mera Gaon Mera Gaurav* programme was undertaken. The progress made under ongoing *Swachhta* activities including implementation of *Swachhta* Action Plan was reviewed. On December 19, 2022, cleanliness and sanitation drive within ICAR-IISR, Lucknow campus

including *Ikshupuri* Residential Colony was undertaken. Disposal status of biodegradable and non-biodegradable waste disposal was reviewed and on the spot solutions were provided to the residents of *Ikshupuri* Residential Colony. On December 20, 2021, status of waste management and other activities including utilization of organic wastes was reviewed. Residents were made aware about composting of waste materials. Clean and green technologies and organic farming practices were advocated for the kitchen gardens of *Ikshupuri* residential colony. On December 21, 2021, awareness on recycling of waste water was created and water harvesting for kitchen gardens of residents in *Ikshupuri* residential colony was created. Awareness for cleanliness and Roof top gardening in nearby areas were created.

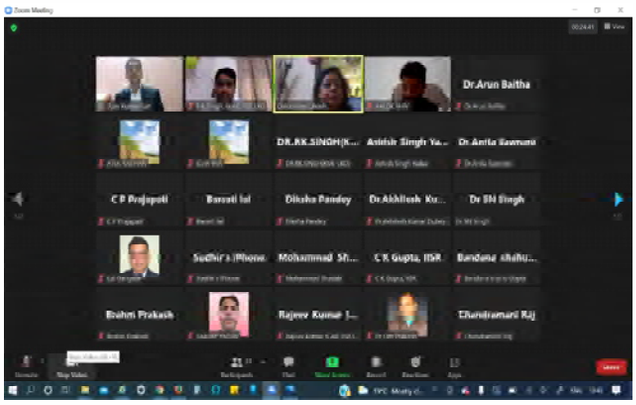
On December 22, 2021, awareness camps and street plays were conducted in nearby villages. Agri-techniques for waste to wealth were explained.

On December 23, 2021, *Kisan Diwas* (Farmer's Day) was celebrated in village Rebha Muradpur, Loni in Hardoi district. Ten sugarcane farmers were honoured on this occasion for exemplary initiatives on *Swachhta*. *Swachhta* campaign was also organized in nearby villages. Fields of few progressive sugarcane farmers were also visited.

On December 24, 2021, *Swachhta* Campaign was organized in a village in Lakhimpur Kheri with the help of farm women.

On December 25, 2021, Kakori Martyr Memorial, Lucknow, a historical place famous for the India's war of independence was cleaned by the IISR staff and students.

On December 26, 2021, a digital talk was organised in the Institute to spread awareness on solid waste management. The talk was given by Prof. Chirashree Ghosh, Department of Environmental Studies, University of Delhi, Delhi on "The source, generation rate & endpoint of covid plastic waste". The talk was initiated by Dr. A.K. Sah, Nodal Officer of *Swachhata Pakhwada* and Principal Scientist. Dr. Ghosh sensitized the listeners about covid plastic waste, its category, its socio-economic impact, status of research in India and abroad, government role and policies and finally how to curb this problem. This talk was organized in online mode through zoom platform in which more than 45 scientists/officers/students/teachers from the Institute, SAU's and Delhi University participated.



On December 27, 2021, drawing and speech competition was organised for the school children on 27th December 2021. The theme of competition was "*Swachha Bharat, Swastha Bharat*", where more than 30 students from the age of 5 years to 14 years participated enthusiastically. Drawing competition for women was also organised on the same day, where mothers of all the participatory children participated actively in the competition and made good drawings as per the theme. Participation certificates and prizes were given to all the participants on the same day while winners of the competition in respective competition and age category were awarded on 30th December 2021 by Mayor of Lucknow, Mrs. Sanyukta Bhatia.

On December 28, 2021, awareness were created on recycling of waste water, water harvesting for agriculture/horticulture applications/kitchen gardens in *Ikshupuri* residential colony. On December 29, 2021, a

team of the Institute comprising 30 staff members, visited The Heartfulness Institute, Shri Ram Chandra Mission Ashram and created awareness on treatment and safe disposal of bio-degradable/non-degradable wastes.

On December 30, 2021, Mrs. Sanyukta Bhatia, Hon'ble Mayor, Lucknow was the Chief Guest in the programme organised in the Institute premises. She planted a tree in the campus and visited the premises to observe the cleanliness in the campus. She was informed that awareness about *swachchhta* was created among 2,500-3,000 persons through various programmes during this fortnight. She thanked the Institute for organizing various competitions for children/students and women to create awareness about *Swachchhta*. She distributed Certificates and Prizes to the 18 winners of Drawing and Speech Competitions organized at the Institute.

On December 31, 2021, a Press Conference was organized at the Institute premises where various activities of *Swachchh Bharat Pakhwara* undertaken by the Institute were highlighted.

Independence Day

The 75th year of Indian Independence was celebrated on August 15, 2021 with great fervour and enthusiasm. At the outset, Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow along with all the Heads of the Divisions offered floral tributes to the Father of the Nation, Mahatma Gandhi. The National Flag was hoisted by Dr. A.D. Pathak, Director of the Institute followed by recitation of the National Anthem by the Scientists, Officers and Staff. Dr. Pathak urged upon all the staff to cherish our coveted freedom and work towards a progressive nation. He extended his warm greetings on the occasion. He informed about the salient achievements made by the Institute for enhancement of sugarcane and sugar production.

Republic Day

The 72nd Republic Day was celebrated at ICAR-IISR, Lucknow on January 26, 2021 with pomp and show, great zeal and enthusiasm. The national flag was unfurled by Dr. A.D. Pathak, Director, ICAR-IISR, amidst loud cheers. The national anthem was sung by all the scientists, officers and staff present on the occasion. Speaking on the occasion, Dr. Pathak highlighted about the significant achievements of the Institute for the last year. All the buildings of the Institute were also decorated and illuminated.

CHAPTER 21

Distinguished Visitors

S.No.	Name of the visitor	Date of visit
1.	Sh. Pramod Kumar Singh, Hon'ble Minister of Sugarcane Industries, Govt. of Bihar, Patna	January 3, 2021
2.	Sh. Surya Pratap Shahi, Hon'ble Minister of Agriculture, Agriculture Education and Research, Govt. of Uttar Pradesh, Lucknow	January 10, 2021
3.	Shri Suresh Chandel, Member , ICAR Governing Body, New Delhi	February 14, 2021
4.	Dr. Sushil Solomon, Ex. Vice Chancellor, CSAUA&T, Kanpur	February 16 and October 21, 2021
5.	Sh. Hriday Narayan Dixit, Hon'ble Speaker, U.P., Legislative Assembly, Lucknow	March 16, 2021
6.	Prof. Surya Prasad Dikshit, Ex. Head, Department of Hindi, University of Lucknow	March 16, 2021
7.	Mr. Suresh Chandra Tiwari, Hon'ble MLA, Lucknow Cantt	May 27, 2021
8.	Dr. Atar Singh, Director, ICAR-ATARI, Kanpur	May 27, 2021
9.	Dr. A.N. Mukhopadhyay, Ex. Vice Chancellor, AAU, Jorhat	October 21-22, 2021
10.	Dr. R.K. Singh, Astt. Director General (CC), ICAR, New Delhi	October 21-22, and November 26-27, 2021
11.	Dr. R.L. Yadav, Ex. Director, ICAR-IISR, Lucknow	October 21-22, 2021
12.	Dr. B.L Jalali, Ex. Director Research, CCSHAU, Hisar	October 21-23, 2021
13.	Dr. Ravi Gopal Singh, Scientist, International Wheat and Maize Improvement Centre, Mexico	October 23, 2021
14.	Dr. S.K. Datta, Ex. Deputy Director General (CS), ICAR, New Delhi	November 26-27, 2021
15.	Dr. N. Vijayan Nair, Ex. Director, ICAR-SBI, Coimbatore	November 26-27, 2021
16.	Dr. S.V. Sarode, Ex. Director of Research, Dr. PDKV, Akola	November 26-27, 2021
17.	Dr. A.K. Vasisht, Ex. ADG (PIM), ICAR, Krishi Bhawan, New Delhi	November 26-27, 2021
18.	Dr. J.P .Mishra, OSD (PP) and ADG (IR), ICAR, Krishi Bhawan, New Delhi	November 26-27, 2021
19.	Dr. A.K. Singh, DDG, Agriculture Extension, ICAR, New Delhi	December 8, 2021
20.	Dr. Y.S. Nerkar, Ex. Vice-Chancellor, MPKV, Rahuri	December 17-18, 2021
21.	Dr. U.K. Behera, Dean, College of Agriculture CAU, Umiam, Meghalaya	December 17-18, 2021
22.	Dr. M.N. Premachandran, Ex. Head, Division of Crop Improvement, ICAR-SBI, Coimbatore (Tamil Nadu)	December 17-18, 2021
23.	Dr. G.T. Gujar, Ex-Head, Division of Entomology, ICAR-IARI, New Delhi	December 17-18, 2021
24.	Dr. Surendra Singh, Ex. Project Coordinator (FIM), ICAR-CIAE, Bhopal	December 17-18, 2021
25.	Dr. K. Anand Reddy, Director (HRD) and PC, PGDM (ABM), National Institute of Agricultural Extension Management (MANAGE), Hyderabad	December 17-18, 2021
26.	Mrs. Sanyukta Bhatia, Hon'ble Mayor, Lucknow	December 30, 2021

CHAPTER 22

Personnel

(As on December 31, 2021)

Director	:	Dr. A.D. Pathak
Crop Improvement		
Principal Scientist and Head	:	Dr. Jyotsnendra Singh (w.e.f. 8th December, 2021)
Principal Scientist (Genetics & Cytogenetics)		Dr. Sangeeta Srivastava
Principal Scientist (Plant Breeding)	:	Dr. P.K. Singh
Principal Scientist (Plant Breeding)	:	Dr. Sanjeev Kumar
Principal Scientist (Genetics)	:	Dr. M. Swapna
Principal Scientist (Agril. Biotechnology)	:	Dr. Sanjeev Kumar
Principal Scientist (Plant Breeding)	:	Dr. Ashutosh Kumar Mall
Senior Scientist (Agricultural Biotechnology)	:	Dr. Ranjit Singh Gujjar
Scientist (Genetics & Plant Breeding)	:	Mr. Aalok Shiv
Scientist (Genetics & Plant Breeding)	:	Mr. Nenavath Krishna Kumar Rathod
Assistant Chief Technical Officer	:	Mr. Raghwendra Kumar
Assistant Chief Technical Officer	:	Dr. Ram Kishor
Technical Officer	:	Mr. Anil Kumar Bansraj Morya
Crop Production		
Principal Scientist & Head	:	Dr. S.K. Shukla
Principal Scientist (Agronomy)	:	Dr. V.P. Singh
Principal Scientist (Agronomy)	:	Dr. T.K. Srivastava
Principal Scientist (Agronomy)	:	Dr. S.N. Singh
Principal Scientist (Agronomy)	:	Dr. A.K. Singh (On deputation)
Principal Scientist (Agronomy)	:	Dr. K.K. Singh
Principal Scientist (Agronomy)	:	Dr. Chandra Gupta
Principal Scientist (Agronomy)	:	Dr. M.K. Tripathi
Principal Scientist (Agronomy)	:	Dr. V.K. Singh
Principal Scientist (Agronomy)	:	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
Senior Scientist (Soil Science)	:	Dr. Ram Ratan Verma
Scientist Senior Scale (Agronomy)	:	Dr. Dileep Kumar
Scientist (Agronomy)	:	Dr. Mona Nagargade
Chief Technical Officer	:	Mrs. Asha Gaur
Assistant Chief Technical Officer	:	Dr. Ram Khilari Singh
Technical Officer	:	Mr. Anil Kumar Singh
Technical Officer	:	Mr. Sanjay Gautam
Technical Officer	:	Mr. Somnath Singh
Crop Protection		
Principal Scientist & Head	:	Dr. Sharmila Roy
Principal Scientist (Agril. Entomology)	:	Dr. M.R. Singh
Principal Scientist (Agril. Entomology)	:	Dr. S.N. Sushil
Principal Scientist (Agril. Entomology)	:	Dr. Arun Baitha
Principal Scientist (Plant Pathology)	:	Dr. Dinesh Singh

Senior Scientist (Plant Pathology)	:	Dr. S.K. Goswami
Scientist Senior Scale (Plant Pathology)	:	Dr. Chandramani Raj
Scientist Senior Scale (Plant Pathology)	:	Dr. Shweta Singh
Chief Technical Officer	:	Mrs. Promila Lal
Agricultural Engineering		
Principal Scientist & Head	:	Dr. A.K. Singh
Principal Scientist (FMP)	:	Dr. R.D. Singh
Principal Scientist (FMP)	:	Dr. S.I. Anwar
Principal Scientist (FMP)	:	Dr. M.K. Singh
Principal Scientist (SWCE)	:	Dr. Rajendra Gupta
Principal Scientist (AS & PE)	:	Dr. Dilip Kumar
Principal Scientist (FMP)	:	Dr. Sukhbir Singh
Scientist (LWME)	:	Er. V.A. Blessy
Scientist (FMP)	:	Dr. Rajesh Uttareshwar Modi
Chief Technical Officer	:	Mrs. Mithilesh Tiwari
Chief Technical Officer	:	Mr. M.H. Ansari
Chief Technical Officer	:	Mr. Rajiv Ranjan Rai
Assistant Chief Technical Officer	:	Mr. Krishna Nand Singh
Senior Technical Officer	:	Mr. Chaman Singh
Technical Officer	:	Mr. Patandin
Plant Physiology & Biochemistry		
Principal Scientist & Head	:	Dr. Pushpa Singh
Principal Scientist (Plant Physiology)	:	Dr. Radha Jain
Principal Scientist (Plant Physiology)	:	Dr. S.P. Singh
Senior Scientist (Plant Physiology)	:	Dr. Chandan Kumar Gupta
Scientist (Biochemistry)	:	Dr. Rajeev Kumar
Chief Technical Officer	:	Mr. C.P. Singh
Senior Technical Officer	:	Mr. Rajendra Kumar Singh
PME Cell & Institute Technology Management Unit		
Nodal Officer & In-charge	:	Dr. L.S. Gangwar
Chief Technical Officer	:	Mr. Brahm Prakash
Chief Technical Officer	:	Dr. Anita Sawnani
AKMU		
Principal Scientist & In-charge	:	Dr. Rajesh Kumar
Principal Scientist (Agril. Economics)		Dr. A.K. Sharma
Principal Scientist (Computer Application)	:	Dr. S.S. Hasan
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
Chief Technical Officer	:	Dr. Om Prakash
Juice Lab		
In-charge	:	Dr. V.P. Jaiswal
HRD Cell		
Nodal Officer	:	Dr. Sangeeta Srivastava
Co-Nodal Officer	:	Dr. Sukhbir Singh
AICRP on Sugarcane		
Project Coordinator	:	Dr. A.D. Pathak
Principal Scientist (Entomology)	:	Dr. S.N. Sushil
Principal Scientist (Entomology)	:	Dr. Arun Baitha

Principal Scientist (Agronomy)	:	Dr. S.K. Shukla
Senior Scientist (Agronomy)	:	Dr. S.K. Yadav
Senior Scientist (Plant Pathology)	:	Dr. Lalan Sharma
Chief Technical Officer	:	Dr. G.K. Singh
Chief Technical Officer	:	Mr. Adil Zubair
Farm Section		
Principal Scientist & In-charge	:	Dr. S.K. Shukla
Farm Managar (Chief Technical Officer)	:	Dr. D.C. Rajak
Technical Officer	:	Mr. Deep Chand
Krishi Vigyan Kendra, Lucknow		
Senior Scientist & Head	:	Dr. Akhilesh Kumar Dubey
Chief Technical Officer/ SMS (Home Science)	:	Dr. (Smt.) Veenika Singh
Chief Technical Officer/ SMS (Plant Protection)	:	Dr. Deepak Rai
Assistant Chief Technical Officer/ SMS (Animal Science)	:	Dr. Rakesh Kumar Singh
Assistant Chief Technical Officer/ SMS (Horticulture)	:	Dr. Viveka Nand Singh
Senior Technical Officer/ SMS (Agronomy)	:	Dr. Sanjay Kumar Pandey
Technical Officer (Farm Manager)	:	Mr. Deep Kumar
Krishi Vigyan Kendra II, Lakhimpur Kheri		
Principal Scientist & Head	:	Dr. Niranjan Lal
Asstt. Chief Technical Officer/SMS (Horticulture)	:	Mr. Arya Desh Deepak Misra
Asstt. Chief Technical Officer/SMS (Plant Protection)	:	Mr. Vivek Kumar Pandey
Art & Photography		
Principal Scientist & In-charge	:	Dr. L.S. Gangwar
Chief Technical Officer	:	Mr. Vipin Dhawan
Chief Technical Officer	:	Mr. Yogesh Mohan Singh
Assistant Chief Technical Officer	:	Mr. Avadhesh Kumar Yadav
Library		
Principal Scientist & In-charge	:	Dr. (Mrs.) Sharmila Roy
Chief Technical Officer	:	Mr. Ghanshyam Ram
Senior Technical Officer	:	Mr. R.N.P. Bharti
Technical Officer	:	Mr. Ashish Singh Yadav
In-charge, Seed Production Unit	:	Dr. Sanjeev Kumar
Security Officer	:	Mr. C.P. Prajapati
Vehicle Section		
In-charge, Vehicle	:	Mr. Raj Kumar
Technical Officer	:	Mr. Kalpnath
Technical Officer	:	Mr. Suresh Kumar
Dispensary	:	
Principal Scientist & In-charge		Dr. A.K. Mall
Landscaping		
In-charge, Landscaping	:	Mr. Rajiv Ranjan Rai
Guest House		
In-charge, Guest House	:	Mr. A.K. Sharma
Manager, Guest House	:	Mr. Ganesh Singh
IISR Regional Centre, Motipur (Bihar)		
Principal Scientist & In-charge	:	Dr. A.K. Mall
Assistant Chief Technical Officer	:	Mr. B.D. Singh
IISR Biological Control Centre, Pravaranagar (Maharashtra)		
Nodal Officer	:	Dr. S.N. Singh

Scientist Senior Scale (Microbiology)	:	Dr. Dnyaneshwar N. Borase
Scientist Senior Scale (Nematology)	:	Dr. Yogesh Eknathrao Thorat
Sugar beet Breeding Outpost, Mukteswar		
Principal Scientist & In-charge	:	Dr. A.K. Mall
Administration		
Chief Administrative Officer	:	Mr. S.K. Singh
Administrative Officer	:	Mr. A.K. Sharma
Finance & Accounts Officer	:	Mr. Ravi Bhadra
Assistant Administrative Officer	:	Mr. R.K. Yadav
	:	Mr. V.P. Tiwari
	:	Mr. Nag Chand
	:	Mr. Prashant Kamal Srivastav
	:	Mr. Hem Chandra Pandey
Private Secretary	:	Mr. Rajeev Arora
	:	Mr. Prem Chandra
	:	Mrs. Veena Sharma

Promotions

Scientist			
1.	Dr. Sukhbir Singh	Principal Scientist	February 19, 2020
2.	Dr. Sanjay Kumar Yadav	Senior Scientist	April 20, 2019
3.	Dr. Lalan Sharma	Senior Scientist	April 27, 2019
4.	Dr. Sanjay Kumar Goswami	Senior Scientist	April 24, 2020
5.	Dr. Ranjit Singh Gujjar	Senior Scientist	April 28, 2021
6.	Dr. Dileep Kumar	Scientist (Senior Scale)	September 15, 2015
7.	Dr. Chandan Kumar Gupta	Senior Scientist	April 20, 2019
8.	Dr. Chandramani Raj	Scientist (Senior Scale)	July 05, 2020
9.	Dr. Shweta Singh	Scientist (Senior Scale)	July 05, 2020
10.	Dr. Yogesh Ekanathrao Thorat	Scientist (Senior Scale)	July 05, 2020
Technical			
1.	Mr. Kulpreet	Technical Assistant	September 7, 2020
2.	Mr. Ashish Singh Yadav	Technical Officer	March 1, 2021
3.	Mr. Sushil Kumar Sharma	Senior Technician	August 1, 2020
4.	Mr. Nand Kishore	Technical Assistant	September 8, 2020
5.	Mr. Brij Kishore	Technical Officer	June 29, 2021
6.	Mr. Patan Din	Technical Officer	June 29, 2021
7.	Mr. Deep Chand	Technical Officer	June 29, 2021
8.	Mr. Arya Desh Deepak Mishra	Assistant Chief Technical Officer	January 19, 2020
9.	Mrs. Promila Lal	Chief Technical Officer	February 24, 2018
10.	Mr. Raghawendra Kumar	Assistant Chief Technical Officer	July 1, 2017
11.	Mr. V.K. Saxena	Assistant Chief Technical Officer	February 24, 2012
12.	Mr. Sanjay Gautam	Senior Technical Officer	March 26, 2018
13.	Dr. Anita Sawnani	Chief Technical Officer	September 27, 2018
14.	Dr. Ram Kishor	Assistant Chief Technical Officer	May 29, 2019
15.	Mrs. Promila Lal	Assistant Chief Technical Officer	February 24, 2011
16.	Dr. Om Prakash	Chief Technical Officer	December 16, 2019
17.	Mr. Rajiv Ranjan Rai	Chief Technical Officer	February 20, 2020
18.	Mr. Atul Kumar Sachan	Chief Technical Officer	February 18, 2020
19.	Dr. Deepak Rai	Chief Technical Officer	September 03, 2017
20.	Dr. Veenika Singh	Chief Technical Officer	August 29, 2017

21.	Dr. Viveka Nand Singh	Assistant Chief Technical Officer	March 07, 2016
22.	Mr. S.N. Srivastava	Assistant Chief Technical Officer	January 1, 2020
23.	Mr. Abhishek Kumar Singh	Senior Technical Officer	September 02, 2017
24.	Mr. Chaman Singh	Senior Technical Officer	July 29, 2017
Administration			
1.	Mrs. Veena Sharma	Private Secretary	July 28, 2021
2.	Mr. Ganesh Prasad	Personal Assistant	July 31, 2021
3.	Mr. Hem Chand Pandey	Assistant Administrative Officer	August 5, 2021

Transfer

Name of Official	From	To	Date of leaving
Dr. Deeksha Joshi	ICAR-IISR, Lucknow	ICAR-IARI, New Delhi	October 8, 2021
Mrs. Manisha Saini	ICAR-IISR, Lucknow	ICAR-IARI, New Delhi	October 8, 2021
Dr. Sanjay Kumar Pandey	KVK, ICAR-CIARI, Nicobar	ICAR-IISR, Lucknow	January 21, 2021

Superannuation

Sl. No.	Name of Official	Designation	Date of retirement
1.	Mr. Makrand Singh	Senior Technician	March 31, 2021
2.	Dr. A.K. Jaiswal	Principal Scientist	April 30, 2021
3.	Mr. Brij Nandan Singh	Skilled Support Staff	April 30, 2021
4.	Mr. S.K. Kushwaha	Chief Technical Officer	May 31, 2021
5.	Mrs. Meena Nigam	Assistant Chief Technical Officer	June 30, 2021
6.	Mr. A.K. Singh	Assistant Chief Technical Officer	July 31, 2021
7.	Mr. Munni Lal	Skilled Support Staff	November 30, 2021
8.	Mr. Shyam Lal	Assistant	December 31, 2021
9.	Mr. Vipin Dhawan	Chief Technical Officer	December 31, 2021

Obituary

Sl. No.	Name of Official	Designation	Date of Death
1.	Mr. Sant Ram	Senior Technical Officer	May 1, 2021
2.	Mr. Kishun Lal	Skilled Support Staff	May 15, 2021

CHAPTER 23

Meteorological Data

Important weather parameters during January 2021 to December 2021 at ICAR-Indian Institute of Sugarcane Research, Lucknow are given below:

Month	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Rainy days (No.)	Bright sunshine hours (hrs./day)	Evaporation (mm/day)	Wind speed (km/hr)
	Maximum	Minimum	at 7:18 am	at 2:18 pm					
January 2021	20.7	7.4	95.6	53.7	0.0	-	4.2	1.2	1.8
February 2021	27.6	10.3	93.0	34.8	6.2	1	7.6	2.7	2.5
March 2021	33.7	16.6	76.9	21.9	1.2	-	8.0	5.5	4.5
April 2021	38.1	19.2	57.5	16.3	17.6	1	9.1	7.7	4.0
May 2021	34.7	24.1	73.5	48.5	85.2	5	7.2	5.3	3.1
June 2021	34.5	26.7	83.3	61.7	142.4	5	5.7	4.1	2.7
July 2021	34.2	26.0	92.3	74.5	144.4	12	4.8	3.7	2.6
August 2021	33.5	26.5	91.2	72.1	200.6	12	3.5	3.1	3.1
September 2021	33.2	25.9	90.0	70.6	357.4	7	6.1	3.3	2.2
October 2021	33.0	21.4	88.6	52.5	104.4	6	7.7	2.9	2.4
November 2021	28.3	12.3	92.4	39.5	0.0	-	6.1	1.8	1.3
December 2021	23.9	9.4	91.9	47.4	7.0	1	4.8	1.4	1.5

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