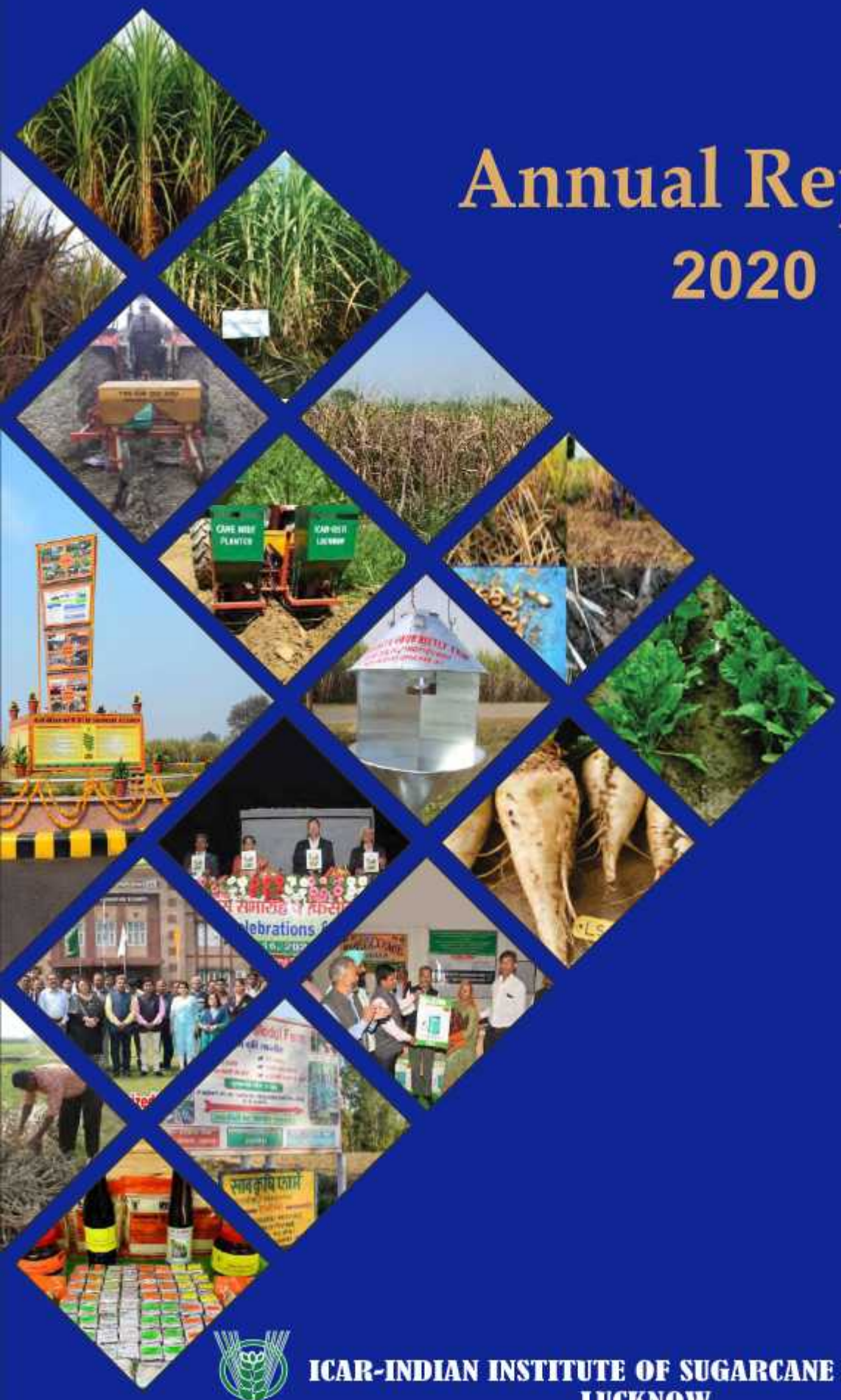
Annual Report
2020



ICAR-INDIAN INSTITUTE OF SUGARCANE RESEARCH
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भाकृअनुप
ICAR

Annual Report

2020

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ISO 9001 : 2015

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From the Director's Desk

By the close of this year 2019-20, the country was in the grip of COVID-19 pandemic along with many other countries of the world. The pandemic has tightened all aspects of doing business including research and development (R &D). The activities in agriculture and supply chains were disrupted. The migrant workers suffered more and agriculture also suffered due to non-availability of labour on account of lockdown. The pandemic once again highlighted the importance of research, challenges of research during crisis period and also the opportunities for making research more efficient and cost-effective. The ICT technology came to rescue in carrying out most of the vital R&D functions. New paradigms and models for research will hopefully emerge from this pandemic. It again highlights the importance of building sustained research infrastructure and a workforce. Despite all these challenges, the Institutes carried out number of activities in its mandated area.

It gives me immense pleasure to present the Annual Report for the year 2020 of ICAR-Indian Institute of Sugarcane Research, Lucknow. I feel it is a privilege to lead a glorious Institute like ICAR-IISR, Lucknow which has made outstanding contributions in the service of the nation in sugar sector and associating itself in making new records for sugar production in India. Despite many impediments and challenges towards scaling up sugar production, our country has created a history by record production of sugarcane. The present Annual Report of the Institute highlights the significant achievements made under different research and developmental programmes.

During the period, under Crop Improvement Programme, a collection of 350 genotypes of sugarcane and 139 sugar beet germplasm has been maintained and enriched over the years. An early maturing sugarcane variety *i.e.* CoLk 14201 (Ikshu -10) was released by the U.P. State Sugarcane Varietal Release Committee for commercial cultivation in Uttar Pradesh. A mid-late maturing sugarcane variety CoLk 14204 (*Ikshu -8*) was identified by the Varietal Identification Committee of AICRP on Sugarcane for its release in North West Zone of India. Efforts towards conservation and further exploration of genotypes have also been made in terms of registration application of genotypes under PPVFR Act 2001 and their inclusion in National Hybridization Garden. *In vitro* cultures of new sugarcane varieties were established and multiplied. Around 8,200 quintals of seed cane was produced and around 12.0 ha area was planted with newly released varieties for seed cane production and popularization.

In Crop Production, diversified sugarcane based cropping/inter-cropping systems were identified and assessed. Sugarcane cropping systems like 150 cm (wide) row spacing + garlic intercropping, systems with medicinal and aromatic plants like Tulsi-Wild Marigold (Two cut) - Sugarcane (spring) - Sugarcane ratoon-Mint cropping sequence, and the Autumn sugarcane based integrated farming system as sugarcane + vegetables + horticultural crop +backyard poultry + fisheries + vermicompost + apiculture + mushroom have been identified as the potential income enhancing cropping systems. In addition, the application of NPK, in split doses, through drip fertigation was found better in increasing the growth parameters and yield. The use of new techniques like nanotechnology, bio-stimulator derivative, microbial cultures and GA_3 have resulted higher yield. The soil properties of the Institute farm were analysed. The long-term rainfall data was compiled and analysed at different centres. Studies on obnoxious weed (*Ipomoea sp.*) management were also carried out.

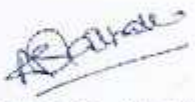
In crop protection the varieties were screened for different diseases and insect-pest incidence. Insect pest and diseases survey were conducted in command areas of sugar mills in Uttar Pradesh. High incidence (30-60%) of red rot in variety Co 0238 was found in cane intensive areas in UP. Two promising *Trichoderma* isolates were identified to enhance sugarcane yield. The studies on faunal build-up in low SOC soils was carried out. Studies on termites and white grubs have been carried out. Studies on whole genome sequence of virulent pathotype (Cf 08) of *C. falcatum* causing red rot to sugarcane are in advance stage.

In Plant Physiology and Biochemistry, the importance of Ethrel and Silica has been established in improvement in germination and biomass dynamics. The drought as well as water logged tolerant sugarcane genoptypes were identified. Drought caused a significant reduction in inter-nodal length and an increase in root density of genotypes. Physiological studies were also carried out on high sugar varieties.

In Agricultural Engineering, different prototypes of planters and ratoon management device, cane node planter and multipurpose tool frame were developed. New prototypes of sugarcane cutter planter and RMD were also developed for tropical region. These machines were field tested for evaluating efficiency. For efficient jaggery production, A efficiency boosting device suitable for IISR two-pan furnace and a sugarcane cleaner-cum-washer unit was fabricated and its performance was evaluated.

In the social science, the disaggregated level analysis has been carried out to spot the potential districts as well as to assess the future sugarcane crop growth scenario in UP. The returns to research due to improved technologies developed by the Institute were estimated. Statistical studies were undertaken for estimating the variability of the experiments on varietal performance in different sugarcane zones in India. Towards digitization, a web-based application, AICRP Reporter, has been developed for online AICRP (S) data recording. Several frontline and on farm demonstrations were conducted on various aspects for disseminating improved sugarcane production technology.

The overall growth and development of the Institute was possible with the able guidance, encouragement and continuous support received from Dr. T. Mohapatra, Secretary, DARE and Director General, ICAR; Dr. T.R. Sharma, Deputy Director General (Crop Science) and Dr R.K. Singh, ADG (CC), ICAR, which I acknowledge with sincere gratitude and reverence. I appreciate the efforts of all the Heads of Divisions, Drs. M.R. Singh, Radha Jain, Sangeeta Srivastava, S.K. Shukla, A.K. Singh, and Incharges, Drs. Rajesh Kumar, L.S. Gangwar, V.P. Jaiswal, A.K. Mall, A.K. Dubey, Niranjan Lal and D.N. Borase for research inputs. I am thankful to the members of Publication Committee, Drs. Sangeeta Srivastava, L.S. Gangwar, A.K. Sharma and Sh. Brahm Prakash for their praiseworthy efforts in bringing out the Report in time. Last but not the least, I am thankful to all staff who are supporting and contributing to the progress of the Institute in the service of the nation.



(A.D. Pathak)
Director

Contents

Executive Summary

Sugarcane varietal development

- An early maturing sugarcane variety *i.e.* CoLk 14201 (*Ikshu* -10) was released by the U.P. State Sugarcane Varietal Release Committee for commercial cultivation in Uttar Pradesh. A mid-late maturing variety CoLk 14204 (*Ikshu* -8) was identified by the Varietal Identification Committee of AICRP on Sugarcane for its release in North West Zone of India. Three early maturing sugarcane clones *i.e.* CoLk 20201 (LG 12201), CoLk 20202 (LG 16070) and CoLk 20203 (LG 14452) and two mid-late maturing clones CoLk 20204 (LG 13002) and CoLk 20205 (LG 14494) were accepted for multi-location testing in North West Zone during the AICRP (S) Workshop. In addition, three genotypes *viz..*, LG 07601, 130 (CoLk 94184 X BO 91) and 150 (CoP 06436 X CoPant 97222) were observed to be quite high yielding (cane weight basis) under irrigated conditions.

Germplasm conservation and maintenance

- A collection of 350 genotypes consisting of *Saccharum officinarum, barberi, sinense* (30 species level genotypes), 51 ISH & *Ikshu* ISH clones, 71 LG selections, 173 commercial hybrids and 25 somaclonal variants was maintained and enriched. Under the PPVFR Act, 2001, applications for the registration and protection of two sugarcane varieties namely, CoLk 12207 (*Ikshu*-6) and CoLk 12209 (*Ikshu*-7) were submitted. Two high sugar genetic stocks, *viz.*, LG 14568 and LG 14419 with mean sucrose % in juice 19-20% during January were identified for further exploration and inclusion in National Hybridization Garden at ICAR-SBI, Coimbatore. A reference collection of 150 sugarcane varieties is being maintained as per DUS testing guidelines. During this year, five 'New' and four "Farmers' Varieties" are under DUS Testing. For sugar beet crop, 139 sugar beet germplasm were maintained and evaluated during the year.

Biotechnological interventions

- *In vitro* cultures of new sugarcane varieties, CoLk 14201 and CoLk 14204 were established and multiplied through enhanced auxiliary shoot proliferation. A total of 3,230 samples including 2,060 samples of banana were tested for genetic fidelity testing under DBT-ATL programme. A total of 1,170 samples comprising of 30 sugarcane and 1,140 banana were tested for mother stock virus indexing. A total of 5,677 non-redundant single dose SNP markers were obtained (using R-package ONEMAP) from which 560 were mapped into 142 linkage groups. Using newly developed polyploid linkage mapping softwares (MAPpoly) and *Saccharum spontaneum* genome, the linkage map was consolidated. Significant positive and negative effect SNPs located on genes involved in sucrose metabolism, photosynthesis, mitochondrial electron transport, glycolysis and transcription have been identified. Comparative analysis showed 43 known and 46 novel differentially expressed miRNA having putative targets of protein binding transcription factors, transporter proteins, enzyme regulator activity, nucleic acid binding transcription factors, disease-resistance proteins and response to stimulii.
- Analysis of whole genome sequence of virulent pathotype (*Cf* 08) of *C. falcatum* causing red rot in sugarcane revealed 617 CAZymes and of these, glycoside hydrolases were the predominant (298). Among 7,264 genes associated with virulence, 77 genes having effector functions were identified. The assembled genome showed its similarity with the genome of *C. graminicola* and *C. higginsianum*, the causal organisms of *Anthracnose* in maize. and in members of Brassicaceae, respectively.
- A comparative transcriptome analysis was performed using leaf samples of control and waterlogged plants of two genotypes, CoLk 94184 (tolerant) and CoJ 64 (sensitive). Total PE reads were 36292012, 34008354, 35079347 and 44466851 in leaves of control, & waterlogged plants of varieties CoLk 94184 and CoJ 64, respectively.

Sugarcane based new cropping systems

- Sugarcane planted at 150 cm row spacing + garlic intercropping in comparison to conventional (90 cm row spacing) sole sugarcane planting recorded 19.53% higher tillers population and were 149.63 thousand /ha at 90 days after planting.DAP shoot count was also 22.64% higher to 137.41 thousand/ha at 120 DAP.
- Diversification of sugarcane based cropping system with medicinal and aromatic plants revealed that the highest wheat equivalent yield (95.5 q/ha) of wild marigold was recorded under *Tulsi*-Wild Marigold (Two cut) - Sugarcane (spring) - Sugarcane ratoon-Mint cropping sequence.
- Autumn sugarcane based integrated farming system (IFS) sugarcane + vegetables +

horticultural crop +backyard poultry + fisheries + vermicompost + apiculture + mushroom fetched net income of ₹ 4,62,412/ha. while spring sugarcane based IFS system fetched net income of ₹ 4,53,350/ha. The income from IFS sole sugarcane was ₹ 2,03,212/ha and ₹ 1,97,550/ha.

Water, nutrient and soil management

- Tillage practice significantly influenced the tiller number at 180 day after initiation of sugarcane ratoon, NMC and yield of sugarcane ratoon. Crop residue management (retention/incorporation of crop residue of previous crop) treatment recorded increase in ratoon cane yield up to 20.88% as compared to without crop residue management (64.36 t/ha). The conventional tillage practice enhanced ratoon cane productivity by 5.7% higher over the zero tillage (70.87 t/ha).
- Application of 100% RDF through drip gave higher cane yield, save irrigation water (40%) and reduced weed infestation (25%) over conventional method of fertilizer and water application in 1st ratoon crop.
- Application of split doses of NPK through drip fertigation was found better in increasing the growth parameters of sugarcane over conventional method. However, maximum benefit of splitting was observed in nitrogen fertilizer.
- 50% RDN + Nitrogen fixing bacteria + Nano N @ 1250 ml/ha in two spray + 100% PK treatment resulted in better growth parameters as compared to other treatments.
- Treatment with 100% NPK + Bio-stimulator derivative @ 2.5 ml/l of water + sett treatment with *Gluconacetobacter diazotrophicus* + sett treatment with *Bacillus subtalis* and *Bacillus cerelus* and foliar application of GA_3 @ 35 ppm at 90, 120 and 150 days after planting found the best practice for achieving higher cane yield (89.43 t/ha).
- The soil properties of Institute farm were analysed. The pH and electrical conductivity varied from 7.57 to 8.22 and 0.14 to 0.25 dS/m. Soil organic carbon content varied from 0.29 to 0.84%, available nitrogen 219.5 to 335.6 kg/ha, phosphorus 14.6 to 53.7 kg/ha and potassium from 197.5 to 350.3 kg/ha with mean values of 0.53%, 258.3, 30.1 and 248.9 kg/ha, respectively. The SOC was positively correlated with available N (0.97) and P_2O_5 (0.42). However, pH was negatively correlated with P_2O_5 (-0.47).
- The long-term rainfall data was compiled and analysed at different centres like Nayagarh, Faridkot, Kolhapur and Coimbatore. The maximum temperature showed significantly increasing trend during August to September at Faridkot, during May at Kolhapur and during October at Coimbatore.

Weed management

- Increasing density of the weed *Ipomoea sp.* adversely affected the yield enhancing attributes of the cane to a significant extent. A density of 10 to 15 *Ipomoea*/m^2 caused the highest reduction in NMC, cane length, cane weight and the cane yield. The varieties CoLk 11206, CoLk 12203, CoPb 14181 and CoPant 14222 showed less than 10% reduction in cane length, girth, weight, NMC and yield highlighting them to have more competitive ability over other varieties under the infestation of *Ipomoea sp.* Among different herbicides applied, application of Flumioxazin 150 g/ha alone or in combination with 2,4-D @ 1500 g/ha as well as Ametryn+2,4-D @ 1500 g/ha or Metribuzin + 2,4-D @ 1250 + 1500 g/ha were effective to control 70-80% other weeds (*Echinochloa colona* and *Dactyloctenium aegyptium*) in addition to 100% control of *Ipomoea* sp.

Sugarcane disease management

- Roving survey of diseases revealed high incidence of red rot in variety Co 0238 in UP. which ranged from 30-50% in affected fields in Gonda and 30-60% in Lakhimpur Kheri area. Sporadic incidences of Yellow leaf disease (5-10%) and smut were also observed in variety Co 0238.
- Two promising *Trichoderma* isolates *viz.* STr-83 (*T. longibrachiatum*) & STr-126 (*T. harzianum*) were identified with the potential to enhance sugarcane yield by 17-24.5% especially under conditions of low inorganic fertilizer usage.
- Micro arthropods were more in number in high SOC soils, than low SOC soils, however, the effect of nutrient sources (inorganic & organic) on faunal build-up was more in low SOC plots. Soil pH and EC ranged between 7.8 and 8.0 and 0.0.06 and 0.13 ds/m.

Insect pest management

- In roving survey of insect pests in UP, sporadic incidences of stalk borer and top borer were found at certain locations in Lakhimpur Kheri.
- Analysis of monthly sampling of termites from 11 designated fields revealed the highest per cent

incidence in August (25.45%) followed by July (22.73%), September (21.82%), October (18.18%) and June (15.45%). The termite incidence was low in January (4.55%) , February (5.45%) and March (7.27%).

- Out of 418 specimens of white grubs collected, 201 were collembolans, 151 were mites, 03 were proturans and rest were other insect juveniles or adults. The *Bacillus thuriengensis* and *Brevibacillu ssp* strains isolated from sugarcane rhizosphere did not show any insecticidal activity against 1st, 2nd and 3rd instar white grubs.
- Lower abundance and diversity of microarthropod fauna in *P. lilacinum* application could be due to the fact that *P. lilacinum*, being pathogenic to nematodes and insects, probably disturbed the soil food chain as Collembolan and mites feed on nematodes and fungi. Amongst the chemical management tools, Chlorantraniliprole (T5) and Imidacloprid (T6) had the least effect on diversity and abundance of studied fauna.
- Pathogenicity studies of *H. indica* IISRBCCH02 revealed that the 150 and 300 IJs per grub were sufficient to kill early and late larval instars of white grub after 3 to 5 days upon EPN inoculation.

Abiotic stress management

- Maximum improvement in germination and biomass dynamics (tiller numbers and biomass accumulation till 210 DAP) was observed with Ethrel as compared to water and control in an experiment with two doses of GA_3, IBA, 6BA and NAA each along with water, ethrel and absolute control.
- Sugarcane genptypes *viz.*, A-27-12, CoLk 94184, CoLk 12204 and CoS 767 were identified as drought tolerant on the basis of relative cane weight. Drought caused a significant reduction in inter-nodal length and an increase in root density of genotypes.
- Physiological studies on high sugar yielding varieties revealed that the maximum photosynthesis rate was recorded in BO 91 (23.9 µmol/m^{-2}/s) which was at par with CoLk 8102 (22.6 µmol m^2/s). The transpiration rate of BO 91 was also maximum and at par with CoLk 9709 (12.8 mmol m^2/s) and CoLk 8001 (12.2 mmol/ m^2/s).). Maximum relative water content was observed in Co 5011 (98.1%) followed by CoLk 9707 (94.7%) which was at par with BO 91 (92.4%) and Co 0238 (93.5%).
- Silica treatments improved germination of buds, root and sheath weight and thus providing hardiness to the plants and enabling them to have some resistance against disease and pest attack. Maximum photosynthesis (16.2 µmol/m^2/s), transpiration (4.4 mmol m^2/s) and stomatal conductance (0.12 mol/m^2/s) was recorded when silica (200 kg/ha) was applied in the form of silicic acid as basal dose.
- Analysis of leaf chlorophyll content under control and waterlogged plants of two genotypes CoLk 94184 (tolerant) and CoJ 64 (sensitive) demonstrated that chlorophyll content ranged between 1.59 and 2.91 mg/g fwt (in control under non-stress-NS condition, and 1.35 and 2.71 mg/g fwt in waterlogged plants suggesting decline in leaf photosynthesis due to waterlogging.

Sugarcane farm machinery development

- Two types of prototypes (with and without stubble shavers) of "tractor operated two row disc type ratoon management device" were developed for carrying out all or some cultural operations such as stubble shaving, off barring and fertilizer application simultaneously in a single pass in a ratoon field having left over trash. The effective field capacity of the machine was 0.30-0.35 ha/h.
- The prototype of multipurpose tool frame with attachments for furrow opening, interculturing and earthing up was demonstrated at farmers' field. The machine has provision for adjustments for cane planted at 75 or 90 cm row spacing. The deep furrowers 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 0.45 ha/h for inter-row inter-culturing with 76% field efficiency. The field capacity of the equipment for earthing up was 0.39 ha/h with field efficiency of 72%.
- Modifications in cane node metering mechanism for metering of pre-soaked cane nodes were carried out in tractor operated cane node planter. The effective field capacity of the planter was 0.15-0.17 ha/h.
- A new prototype of two row deep furrow sugarcane cutter planter was developed for

tropical region with adjustable row spacing of 120 and 150 cm. 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. Similarly, prototype of disc type ratoon management device (Disc RMD) was modified for tropical region. Its fertilizer metering mechanism was modified to make it suitable for metering of fertilizer in high ridge fields. It was equipped with stubble shaving serrated blades mounted on a disc, two tillage discs for off-barring on either side of the stubbles and fertilizer metering device for application of fertiliser at root zone. Performance trials of these machines were conducted at the farm of ICAR-SBI, Coimbatore.

- A prototype of manually operated weedicide sprayer was fabricated. A 12V battery and a pump was attached under the tank of 15 litre capacity that act as a reservoir for herbicide solution.
- Thirteen tractor operated prototypes and 12 manual operated prototypes were fabricated. Two IISR tractor operated customized deep furrow sugarcane cutter planter, 7 IISR manual bud chipper and one IISR manual cane node cutter cum bud scooper were supplied to different organizations/individuals.
- A prototype of pedal operated paddy thresher was designed and developed for threshing of paddy with the facility of detaching pedal operating assembly from the main frame. The machine has provision of small ground wheels to help during transportation. Fan is also provided to help in winnowing of the paddy grain after threshing. The capacity of machine was observed 1.0 q/h.

Efficient jaggery production

- A sugarcane cleaner-cum-washer unit was fabricated and its performance was evaluated with three sets of speed of scrapping rollers.
- The scale-up model of efficiency boosting device for IISR two-pan furnace was fabricated. The best performance of furnace was obtained with EBD valve fully open and WHRS valve fully closed due to all air moving through EBD generating more force and giving better effect.
- Design of IISR model jaggery unit for enhanced capacity was finalized for 150 kg jaggery production per batch.

Sugar beet varietal development

- A total of 50 sugar beet entries were screened for major insect-pest army worm (*Spodoptera litura*) infestation and foliar diseases like *Alternaria* sp and *Cercospora betae* causing leaf spot diseases. Out of these, 15 entries were found to be severely infected (40% disease incidence) with *Alternaria* leaf spot and 15 entries showed 35-40% disease incidence for *Cercospora* leaf spot. The sugar beet variety SV 892 was found to be moderately resistant against *S.litura*.

Economics and statistics

- The returns to research due to sugarcane cutter planter were estimated at ₹ 35.1 per rupee invested. The benefits in monetary terms with adoption of variety CoLk 94184 having 2 lakh ha area in UP and Bihar was ₹ 411 crores. The economic saving by using integrated control measures for woolly aphid in an area of around 3.0 lakh ha of severely infested sugarcane area in Maharashtra and Karnataka was ₹ 1056 crores per year for an average 80 t/ha yielding sugarcane crop.
- For assessing future sugarcane crop growth scenario in UP, the largest sugarcane growing state, the disaggregated analysis at the district level revealed that the districts of Pilibhit, Bareilly, Sitapur, Kheri, Bahraich, Gonda, Hardoi, Shravasti, Kasganj and Ghazipur exhibited positive growth in sugarcane area as well as in productivity during last 10 years.
- Statistical studies were undertaken for estimating the variability of the experiments on varietal performance in different sugarcane zones in India. The cane yield CV varied from 0.07 to 32.29% and the cane yield CD varied from 0.05 to 66.66. The sucrose (%) CV and CD varied from 0.02 to 27.53% and from 0.02 to 9.3%, respectively.
- Statistical studies on experimental plot design trial conducted separately with same number of varieties revealed that Alpha lattice design was more efficient as compared to complete randomized block design.

Digitization and web-based applications

- AICRP Reporter (A web-based application) has been developed to provide an effective data recording and reporting platform for AICRP on Sugarcane. The data of Zonal Varietal Trials (Sugarcane) for the year 2019-20 was collected through this software using both online data recording and through excel file generation from all AICRP (S) centres.

- An app has been developed and uploaded on the Institute website.
- The boundary lines of the Institute research farm were digitized by geo-referencing for development of soil properties maps.

Technology demonstration

- Three field days were organized in Uttar Pradesh and Bihar. Several frontline demonstrations were conducted on various aspects for disseminating improved sugarcane production technology. The assessment of PGR technology in autumn planted sugarcane on farmer's field revealed an increase in germination, initial shoot population and tillers count at 38.10, 30.43 and 38.66 per cent, respectively. It also resulted in increase in other growth parameters like cane length (10.22%) and cane girth (17.78%). The increase in the cane yield level was quite impressive at 61.97 per cent resulting in an increase of 82.28 per cent in net profit. The application of ethrel was beneficial in enhancing quality parameters in terms of increase in pol% (4.06% in juice and 4.07% in cane). Under demonstration of sugarcane intercropping technology, tomato grown as intercrop with sugarcane recorded maximum net profit of ₹ 4,64,500/ha with B:C ratio 2.58 in comparison to net profit of ₹ 2,07,500/ha with B:C ratio of 1.48 under mustard intercropping, and net profit of ₹ 1,60,000/ha as sole sugarcane crop.
- Demonstrations on seed cane revealed overall average net profit and B:C ratio at ₹ 2,82,555 per ha and 2.35, respectively in comparison to average net profit ₹ 1,43,750 per ha and B:C ratio of 1.44 under conventional method. The variety Co 0118 has maximum profit of ₹ 3,33,459/ha while CoS 08279 provided the minimum profit of ₹ 2,28,367/ha.
- An attempt for assessing entrepreneurial spirit among farmers was made and considerable increase in all attributes of Entrepreneurship Behaviour (EB) was recorded. However, the maximum increase of 52.87% was recorded in Achievement Motivation attribute of EB. The overall Entrepreneurship Behaviour Index was observed to increase by 32.67%.

Seed production

- Around 8,200 quintals of seed cane was produced and 12 ha area was planted with newly released varieties for seed cane production and popularization.
- Under Bihar Sugarcane Breeder Seed Production, nearly 34,000 quintals of seed cane was produced and distributed to different agencies in Bihar.

About the Institute

The ICAR-Indian Institute of Sugarcane Research (IISR), Lucknow was established on February 16, 1952 by the erstwhile Indian Central Sugarcane Committee for conducting research on fundamental and applied aspects of sugarcane culture as well as to co-ordinate research work done on this crop in different states of the country. The Government of India took over the Institute from the Indian Central Sugarcane Committee on January 1, 1954, and thereafter, it was transferred to the Indian Council of Agricultural Research (ICAR), New Delhi on April 1, 1969. The Institute is located in Lucknow, the capital city of Uttar Pradesh and 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 total factor productivity

Strategies

Increasing the level of cane yield and sugar recovery

a. Introgression of untapped genes in the parental gene pool

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

c. Improving sink strength and source efficiency

d. Enhancing productivity of ratoon cane

Reducing the cost of cane cultivation

a. Nutrient use efficiency through rhizospheric engineering and INM technology

b. Water use efficiency through micro-irrigation

c. Land use efficiency though companion cropping

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

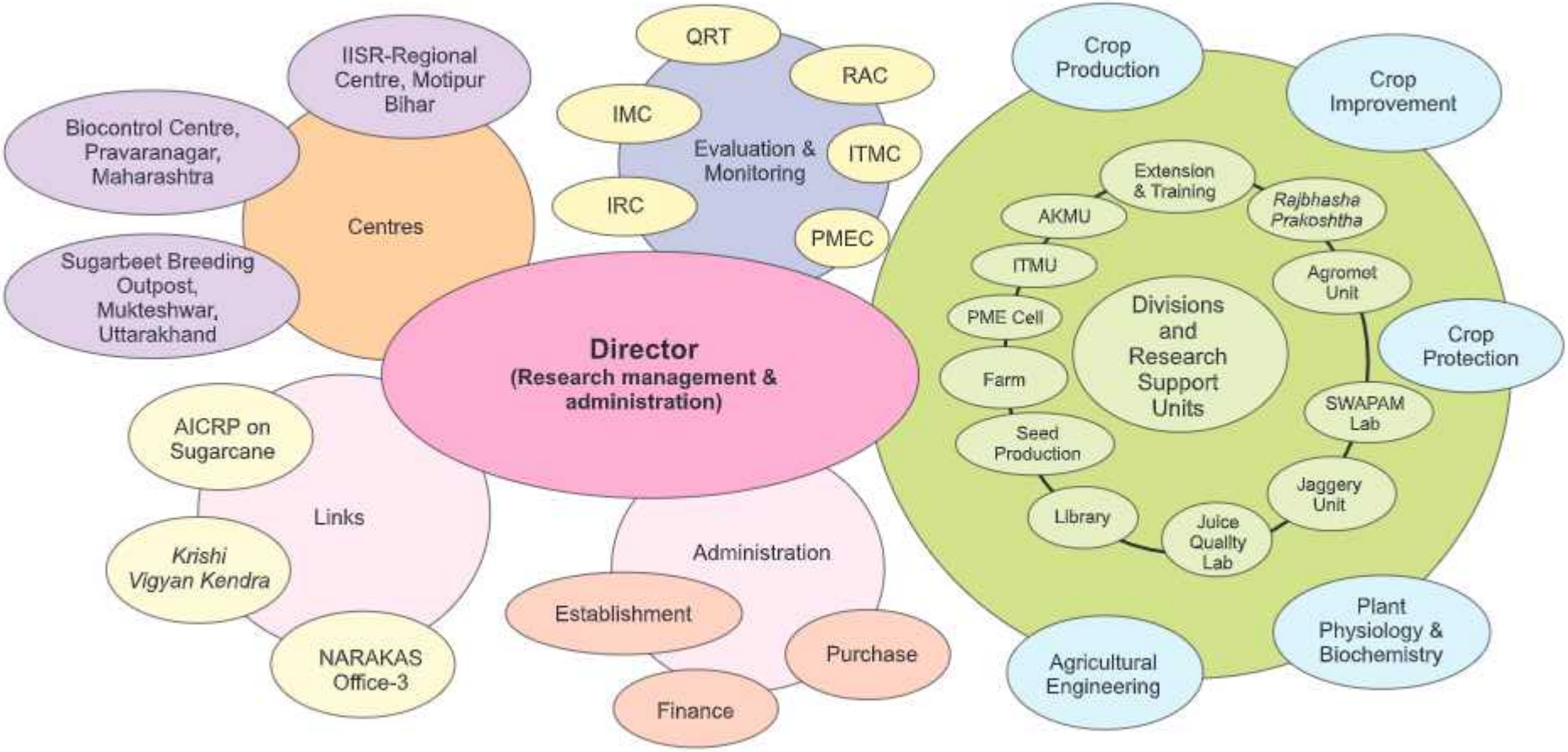
e. Mechanizing sugarcane farming

Arresting decline in total factor productivity

a. Soil biological and nutritional dynamism

b. Carbon sequestering through cropping system

ICAR-Indian Institute of Sugarcane Research, Lucknow



Organizational Structure

Budget : 2019-20

Particulars	Plan (₹ in lakh)	
	Revised Estimate	Expenditure as on March 31, 2020
ICAR - Indian Institute of Sugarcane Research	7478.00	7387.21
All India Coordinated Research Project on Sugarcane	948.64	940.82

Budget : 2020-21

Particulars	Plan (₹ in lakh)	
	Revised Estimate	Expenditure as on December 31, 2020
ICAR - Indian Institute of Sugarcane Research	8178.00	6400.00
All India Coordinated Research Project on Sugarcane	952.30	712.95

Staff position

Category	Sanctioned	Filled	Vacant
Research Management Position	1	1	0
Scientific			
Principal Scientist	7	4	3
Senior Scientist	14	15	-1
Scientist	53	47	6
Total	74	66	8
Technical			
Cat. I (T-1)	77	37	40
Cat. II (T-3)	54	31	23
Cat. III (T-6)	3	1	2
Total	134	69	65
Administrative	50	37	13
Skilled Supporting Staff	36	09	27
Total	294	181	113

CHAPTER 1

Genetic Improvement of Sugarcane for Higher Cane and Sugar Productivity

In recent years, there has been an improvement in sugar yield in India, along with substantial genetic improvement for disease resistance through traditional breeding methods. However, genetic gain for key traits, particularly sucrose content and cane yield has been stagnating. Present day sugarcane cultivars have been developed from a few inter-specific crosses, thus, limiting chromosomal recombination. Generating the variability using hitherto unused genetic resources is required for introgression of new genes into the existing genetic background, to enhance the sugar accumulation potential as well as improvement in other economic traits in the newly developed genotypes. Pre-breeding strategies in the past have generated potential genetic stocks and improved parental clones are needed to ensure sustainable improvement and maintain the diversity. State of the art molecular tools are being used to further augment the sugarcane breeding programmes.

Technology developed

Identification/Release of sugarcane varieties

An early maturing sugarcane variety *i.e.* CoLk 14201 (*Ikshu*-10) was released by the U.P. State Sugarcane Varietal Release Committee for the commercial cultivation in Uttar Pradesh.

Another mid-late maturing sugarcane variety CoLk 14204 (*Ikshu*-8) was identified by the Varietal Identification Committee of All India Coordinated Research Project on Sugarcane for its release in North West Zone of India. Salient features of these two varieties are given in Table 1.1.

Registration of sugarcane varieties

Two sugarcane varieties namely, CoLk 12207 (*Ikshu* -6) and CoLk 12209 (*Ikshu*-7) were applied for registration under the Protection of Plant Variety and Farmers Right Act, 2001 for their protection. The duly filled applications of aforesaid varieties have been submitted to the Protection of Plant Variety and Farmers Right Authority, New Delhi.

Sugarcane clones accepted for multi-location testing

Three early maturing sugarcane clones *i.e.* CoLk 20201 (LG 12201), CoLk 20202 (LG 16070) and CoLk 20203 (LG 14452) and two mid-late maturing clones *i.e.* CoLk 20204 (LG 13002) and CoLk 20205 (LG 14494) were accepted for multi-location testing in North West Zone during online meeting of AICRP (S) Workshop-2020 organized by ICAR-IISR, Lucknow. Salient features of these clones are given in Table 1.2. Four entries for two maturing groups namely LG 901, LG 902 (Early) and LG 903, LG 904 (Mid-late) were also accepted in Zonal Varietal Trial (NCZ) during 33rd Biennial Workshop of AICRP (S) on October 20, 2020.

Table 1.1. Salient features of CoLk 14201 (*Ikshu* -10) and CoLk 14204 (*Ikshu*-8)

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

Table 1.2. Salient features of the accepted clones

Clone	Parentage	Maturity group	Cane yield (t/ha)	CCS yield (t/ha)	Sucrose % at harvest	Red rot rating
CoLk 20201 (LG 12201)	CoSe 92423 x CoS 96260	Early	97.88	13.27	19.32	MR
CoLk 20202 (LG 16070)	LG 05823 GC	Early	98.24	12.91	18.81	MR
CoLk 20203 (LG 14452)	LG 01118 x LG 05460	Early	91.84	12.28	19.07	MR
CoLk 20204 (LG 13002)	CoH 104 GC	Mid-late	94.23	12.67	19.39	MR
CoLk 20205 (LG 14494)	LG 05433 x LG 97022	Mid-late	92.47	12.66	19.59	MR
LG 901	CoSe 95422 x Co 62198	Early	97.90	11.34	17.30	MR
LG 902	CoSe 95422 x Co 62198	Early	97.80	11.37	17.34	MR
LG 903	CoJ x 80 Co 86011	Mid-late	97.70	11.23	18.26	MR
LG 904	CoSe 95422 x Co 62198	Mid-late	89.60	11.21	18.02	MR

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

The collection of 350 genotypes consisting of *Saccharum officinarum, barberi, sinense*, ISH clones, *Ikshu* ISH clones, LG selections, commercial hybrids and somaclonal variants *etc.*, was maintained and the required material was supplied to various on-going projects of the Institute. It includes 173 Commercial hybrids, 51 ISH & *Ikshu* ISH lines, 71 LG Clones, 30 species level genotypes and 25 somaclonal variants.

Defining ideotypes in sugarcane for moisture deficit condition

A total of 28 progenies of bi-parental, self and general crosses of *Saccharum* hybrid including five check varieties were planted for assessment of yield and juice quality in RBD with three replications under irrigated and drought conditions during 2019-20. All the recommended cultural practices were adopted to raise good and healthy crop. On the basis of the cane weight, out of twenty four genotypes, the genotypes *viz.*, LG 07601, 130 (CoLk 94184 X BO 91) and 150 (CoP 06436 X CoPant 97222) performed the best against the four checks (CoSe 95422, CoP 06436, CoP 9301 and CoLk 94184) under irrigated condition while the genotypes *viz.*, 52 (CoS 8436 X Co 1148), 130 (CoLk 94184 X BO 91) and 44 (LG 05460 X CoSe 95422) genotypes showed better performance against checks under drought condition. However, sucrose content was the highest in the genotypes *viz.*,130 (CoLk 94184 X BO 91) and 143 (CoP 06436 X BO 130) in irrigated condition; and the genotypes *viz.*,130 (CoLk 94184 X BO 91), 120 (BO 91X Co 62198), 36 (LG 05460 X CoSe 92423) and D 2-1 showed better performance against check varieties under drought condition. A similar pattern of results was observed for Brix and purity (%) under both irrigated and drought conditions. The genotype 130 (CoLk 94184 X BO 91) maintained its superiority under both the conditions for sucrose content, Brix, purity (%) and commercial cane sugar (%).

Development of sugarcane varieties for sub-tropics

Hybridization and seedling raising

A total of 28 bi-parental sugarcane crosses and 45 GCs were proposed for the crossing season 2020 and list of the same was sent to In-charge, National Hybridization Garden, ICAR-SBI Coimbatore. Fluff of these crosses will be sown in the glass/poly house for the seedling raising. Approximately 30,010 seedlings derived from 27 biparental crosses, 08 PCs, and 38 GCs were raised and transplanted in the field condition for their evaluation.

Selection in seedling (C_0) population

Based on the HR brix and other growth parameters, a total of 520 clones were selected from the seedling populations. These selected clones have been planted during autumn season as C_1clones along with standard varieties for their further evaluation.

Evaluation of advanced clonal generations

About 32 promising sugarcane clones selected in C_2 generation and promoted to the C_3 generation are being under evaluation for yield, quality parameters and resistance to red rot disease. A total of 186 clones are under evaluation in C_2 generation for their growth and quality parameters.Similarly, 176 C_1 clones are also under evaluation. Observations on germination %, tiller and shoot counts, NMCs and early stage quality parameters were recorded.

Station Trial (2020)

Ten elite sugarcane genotypes *i.e.* LG 13431, LG 14418, LG 14497, LG 15166, LG 15265, LG 16169, LG 17129, LG 17130, LG 17154 and LG 17179 along with six standard varieties *i.e.* Co 0238, Co 05009, CoJ 64, CoS 767, CoPant 97222 and Co 05011 are under evaluation in the Station Trial (2020-21) for their growth, yield and quality parameters. Observations on germination %, tiller and shoot counts, NMCs and early stage quality parameters were recorded.

Evaluation of early sugarcane clones for North West Zone

Initial Varietal Trial (early)

A trial comprising of nine test sugarcane genotypes *i.e.* Co 15025, Co 16029, CoLk 16201, CoLk 16202, CoPb 16211, CoPant 16221, CoPant 16222, CoPb 16181, and CoS 16231 and three standards *i.e.* CoJ 64, Co 0238 and Co 05009 was conducted and observations were recorded on various yield and quality parameters. CoPant 16222 recorded the highest cane yield (129.35 t/ha) closely followed by CoPant 16221 (122.65 t/ha). The genotype CoLk 16202 had shown the highest CCS yield (14.48 t/ha) followed by CoPant 16222 (13.06 t/ha). The highest sucrose content at harvest was recorded in Co 15025 (17.44%) followed by Co 16029 (17.26%). Among the standards, Co 0238 was found the best standard for both yield and quality parameters and recorded the highest cane yield (96.06 t/ha) and CCS yield (11.87 t/ha).

Advanced Varietal Trial I Plant (Early)

Six sugarcane genotypes *viz.*, Co 15023, Co 15024, Co 15027, CoLk 15201, CoLk 15205 and CoPb 15212 along with three standards *viz.* CoJ 64, Co 0238 and Co 05009 were evaluated for yield and quality parameters Among the test genotypes, CoLk 15201 recorded the highest both cane yield (100.44 t/ha) and CCS yield (13.21 t/ha). The genotype CoLk 15205 showed the highest sucrose percentage at harvest (18.87 %) followed by CoLk 15201 (18.83 %). Among the standards, Co 0238 was the best checks for cane yield (82.88 t/ha) and CCS yield (10.50 t/ha).

Advanced Varietal Trial II Plant (Early)

Four sugarcane clones *viz.*, Co 14034, CoLk 14201, CoPb 14181 and CoPb 14211 along with three standards CoJ 64, Co 0238 and Co 05009 were evaluated for yield and quality parameters. Among the test genotypes, CoLk 14201 recorded the highest cane yield (85.49 t/ha) and CCS yield (10.91 t/ha). The genotype CoPb 14181 showed the highest sucrose percentage at harvest (18.86%) followed by CoPb 14211 (18.79%). Among the standards, Co 0238 was the best check for cane yield (85.15 t/ha) and CCS yield (10.58 t/ha).

Advanced Varietal Trial Ratoon (Early)

Four sugarcane clones *viz.*, Co 14034, CoLk 14201, CoPb 14181 and CoPb 14211 along with three standards CoJ 64, Co 0238 and Co 05009 were evaluated for their ratooning ability. The genotype, CoLk 14201 showed the highest cane yield (79.43 t/ha) and CCS yield (10.96 t/ha). Among the standard varieties, Co 0238 was the best for cane yield (79.04) and CCS yield (10.53).

Seed Multiplication (Eearly)

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

Evaluation of mid-late sugarcane clones for North West Zone

Initial Varietal Trial (Mid-late)

Seven sugarcane clones *viz.*, Co 16030, CoLk 16203, CoLk 16204, CoPb 16212, CoPant 16223, CoS 16232 and CoS 16233 along with three standards *viz.*,, CoS 767, CoPant 97222 and Co 05011 were evaluated for yield and quality parameters. The genotype CoPant 16223 recorded the highest cane yield (124.04 t/ha) followed by CoS 16232 (108.28 t/ha) and CoLk 16203 (105.90 t/ha). The genotype CoPant 16223 showed the highest CCS yield (14.19 t/ha) followed by CoS 16232 (12.85 t/ha) and CoLk 16203 (12.83 t/ha). Among the test genotypes, Co 16030 recorded the highest sucrose percentage at harvest (17.65%) followed by CoLk 16203 (17.64%) and CoLk 16204 (17.37%). Among the standard varieties, Co 05011 recorded the highest CCS yield (12.16 t/ha) followed by CoPant 97222 and CoS 767.

Advanced Varietal Trial I Plant (Mid-late)

Seven sugarcane genotypes *viz.*, Co 15026, CoLk 15206, CoLk 15207, CoLk 15209, CoPb 15213, CoS 15232 and CoS 15233 along with three standards *viz.*

CoS 767, CoPant 97222 and Co 05011 were evaluated for yield and quality parameters. CoLk 15206 recorded the highest cane yield (95.44 t/ha) which was significantly superior to the best check. CoLk 15207 exhibited the highest sucrose % at harvest (19.58%) followed by CoPb 15213 (19.42%) and CoLk 15206 (19.34%). Among the standard varieties, CoS 767 was found best for cane yield (73.58 t/ha) and Co 05011 for CCS yield (9.49 t/ha).

Advanced Varietal Trial II Plant (Mid-late)

Seven sugarcane genotypes *viz.*, Co 14035, CoH 14261, CoLk 14203, CoLk 14204, CoPb 14184, Co 14185 and CoS 14233 along with three standards *viz.* CoS 767, CoPant 97222 and Co 05011 were evaluated for yield and quality parameters. CoLk 14203 recorded the highest cane yield (117.44 t/ha) which was significantly superior to the best check. Co 14035 exhibited the highest sucrose % at harvest (19.89%) followed by CoPb 14185 (19.53%) and CoH 14261 (19.35%). Among the standard varieties, CoS 767 was found best for cane yield (84.29 t/ha) and CoPant 97222 for CCS yield (10.87 t/ha).

Advanced Varietal Trial Ratoon (Mid-late)

Seven genotypes *viz.*, Co 14035, CoH 14261, CoLk 14203, CoLk 14204, CoPb 14184, Co 14185 and CoS 14233 along with three standard varieties CoS 767, CoPant 97222 and Co 05011 were evaluated for their ratooning ability. The genotype CoLk 14203 had shown the highest cane yield (92.30 t/ha) and CCS yield (12.24 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 fifteen genotypes *viz.*, Co 17018, CoH 17261, CoH 17262, CoLk 17204, CoLk 17205, CoPb 17213, CoPb 17214, CoPb 17215, CoPant 17223, CoPant 17224, CoS 17233, CoS 17234, CoS 17235, CoS 17236 and CoS 17237is being multiplied for next year's IVT trial.

Development of sugarcane clones/varieties for North Central Zone

Forty five different cross combinations (BP, GC & PC) were attempted. Fluff has been sown for raising seedlings. (Fig. 1.1) The seedlings of crosses attempted in 2018-19 were raised successfully and during this year, progenies of crosses are in C_1 stage. For further quality evaluation, juice analysis was performed. Eleven entries were selected on the basis of previous year's juice analysis data and a station trial was laid out including five checks in RBD with three replications at RC, Motipur. The observations on various traits were also recorded for further selection.

Fig. 1.1 Fluff germination of different cross combinations of sugarcane at IISR Regional Centre, Motipur, Bihar

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

Micropropagation technique of plant tissue culture assumes significance for rapid multiplication of new varieties with superior traits and production of disease-free genetically uniform seed cane. This year, *in vitro* cultures of new sugarcane varieties CoLk 14201 and CoLk 14204 were established and multiplied through enhanced axillary shoot proliferation using apical shoot explants on Murashige and Skoog's medium supplemented with 4.44 µM benzyladenine (BA) and 4.6 µM kinetin (Kin) + 3% sucrose. The previously established sugarcane varieties CoLk 09204, CoLk 11203, CoLk 11206, CoLk 12207 and CoLk 12209 were multiplied (100% shoot regeneration frequency) 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 were acclimatized and finally transferred to field conditions for further multiplication as disease-free 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°C on MS medium supplemented with 2.22 µM BA, 0.5 µM Kinetin, 0.5µM GA_3, 5% sucrose and 5.0 µM flurprimidol (a chemical growth retardant). The cultures could be stored for up to 365 days without any sub-culture. After slow-growth period, the green parts of the cultures could be regenerated on MS medium with 2.22 µM BA, 0.5 µM Kinetin, 0.5 µM GA_3 and 3% sucrose. Successful shoot multiplication without any genetic variation in the recovered cultures was recorded from such stored slow-growing shoots incubated for 360 days.

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

An Accredited Test Laboratory (ATL) under operation at IISR, Lucknow with the financial support from Department of Biotechnology (DBT), New Delhi under National Certification System of Tissue Culture-raised Plants (NCS-TCP), aims to enhance the production and distribution of tissue culture-raised genetically uniform and virus-free planting materials to the farmers through commercial tissue culture units. During the year, a total of 3,230 samples were tested of which 1,170 samples comprising of 30 of sugarcane and 1,140 of banana from DBT recognized tissue culture production facilities were tested for mother stock virus indexing. Of the total samples, 2,060 samples of banana were tested for genetic fidelity testing, which equals to quality certification of 50 lakh tissue culture plantlets, for which test reports, certificate of quality as well as quality labels were issued. 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).

Mapping of loci linked to sugar content in sugarcane

This project aims to develop high sugar sugarcane genetic stocks and also to carry out molecular mapping of loci linked to sugar content, using segregating populations. The high sugar genotypes evaluated during 2019-20 exhibited variation for cane and sugar yield. Out of the 250 genotypes evaluated in different clonal stages, 22 genotypes exhibited mean sucrose% juice values more than 19.5% at harvest (Table 1.3). These are being assessed further in 2020-21 for their performance and suitability as genetic stocks and/or varietal candidates. Around 160 clones in different maturity groups were selected and advanced for evaluation in 2020-21. Seven clones moderately resistant to red rot disease were identified among 30 clones tested.

During 2020, an advanced trial of 30 genotypes with mean sucrose % in juice values 19% or more at harvest were evaluated. All these genotypes qualified as early maturing (in January) or mid-late maturing (in February-March) genotypes. Another experiment evaluated approximately 160 genotypes in the third and fourth clonal stages that were advanced from the previous year. The high sugar genotype LG 08422 (CoLk 15205) was found to be promising in the multi-location trials for sugar accumulation. The progeny populations form the matings involving CoLk 15205 were found to have a high proportion of high sugar clones.

Hand Refractor meter Brix readings were recorded in October-November in the 160 genotypes and the promising clones have been earmarked. The morphological studies and juice analyses were initiated. Approximately 20 clones were identified with high sucrose content (>17% sucrose in juice) in November from various trials. Three promising clones LG 13431, LG 14497 and LG 14418 were evaluated in the divisional station trial for probable inclusion in AICRP (Sugarcane) multi-location trials.

Two high sugar genetic stocks, *viz.*, LG 14568 and LG 14419 with mean sucrose % in juice values 19-20% during January were identified for inclusion in National Hybridization Garden at ICAR-SBI, Coimbatore. Fifteen bi-parental crosses, general collections and selfs involving the newly included high sugar genetic stocks were proposed during this flowering season at NHG, ICAR-SBI, Coimbatore.

Thirty promising genotypes in different clonal stages are being tested for reaction to red rot disease. Segregating populations for molecular marker studies were maintained in the field for laboratory studies. The mean sucrose % in juice at harvest varied from 8.8% to 20.9%. Genotyping studies have been initiated using a self-population.

Table 1.3. Performance of promising high sugar genotypes (C, stage) for sugar content

Sl. No.	Genotype	Sucrose % in juice at harvest	CCS%
1	II-28-17	20.1	14.04
2	II-22-02	19.8	13.82
3	I-41-5	19.9	13.88
4	II-16-01	19.5	13.65
5	III-24-1	19.6	13.71
6	III-21-7	19.5	13.50
7	I-20-5	19.9	14.04
8	III-20-3	20.4	14.36
9	III-25-10	20.1	14.14
10	IV-35-6	19.8	13.85
11	III-18-2	19.6	13.68
12	I-2-10	19.8	13.61
13	III-17-5	19.5	13.58
14	V-18-3	19.8	13.92
15	III-24-9	19.7	13.64
16	III-11-4	19.8	13.93
17	V-7-8	20.1	14.14
18	IV-3-11	20.9	14.70
19	IV-23-2	20.5	14.41
20	IV-33-8	20.2	14.13
21	III-17-6	22.0	15.45

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

Genotyping by sequencing (GBS)-based linkage map of sugarcane was prepared for identifying QTLs linked to sucrose and other agronomically important traits using *Saccharum* spp. hybrid genome (Garsmeur *et al.*, Nature Comm. 2018:9(1):2638) as a reference. For GBS, DNA from 131 F_1 individuals and their two parental genotypes (CoV 92102 and MS 68/47) was digested with *Ape*K1 and the GBS library was prepared from the digested DNA by ligating specific adaptors to the cut-site. The library pools were sequenced on Illumina HiSeq 2000 platform to generate an average of 0.9 GB data per sample. Using ONEMAP (R-package), a total of 5677 non-redundant single dose SNP markers were obtained from which 560 were mapped into 142 linkage groups. This has been followed by consolidating this linkage map using newly developed polyploid linkage mapping softwares (MAPpoly) and *Saccharum spontaneum* genome (Zhang *et al.*, Nature Genetics 2018:50:1565-1573) reference assembly and study of genotype-phenotype interaction (Fig.1.2). Additionally, BSRseq has been employed to identify differentially expressed genes (DEGs) and SNPs associated with sucrose accumulation using high and low sugar parents and two bulks with extremes for sucrose accumulation obtained from their F_1 segregating population. Significant positive and negative effect SNPs located on genes involved in sucrose metabolism, photosynthesis, mitochondrial electron transport, glycolysis and transcription have been identified. Among the differentially expressed genes, sucrose phosphate synthase III, genes involved in transport, auxin signal transduction, *etc.*, were upregulated, while those involved in electron transfer, cytochrome P450, *etc.*, were downregulated in early sucrose accumulation conditions (Fig. 1.3, 1.4). This study would be able to give finer insights in to the role of allelic heterozygosity on sucrose accumulation and the identified NSVs and DEGs could be useful as candidate markers in marker-assisted breeding for developing high sugar varieties.

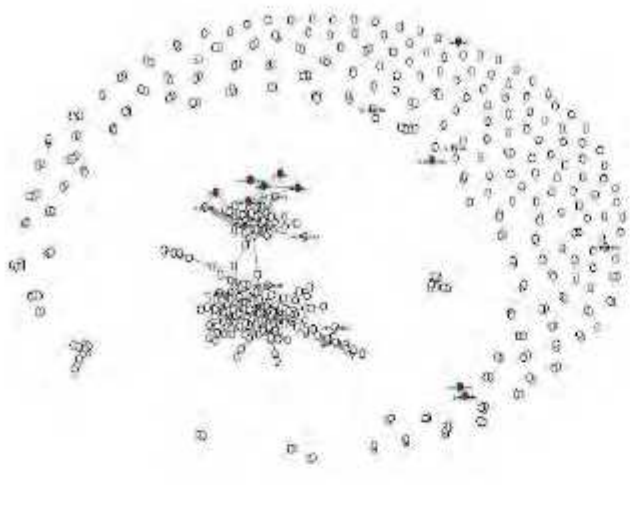


Fig. 1.2. Use of unidirectional graphical models for linkage map construction based on 'gibbs' method for high-dimensional genotype-phenotype network study using R-package 'netgwas'

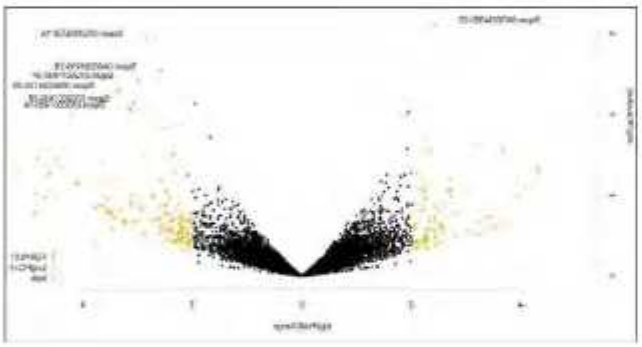


Fig. 1.3. Differentially expressed genes mapped on *Saccharum spp.* hybrid genome

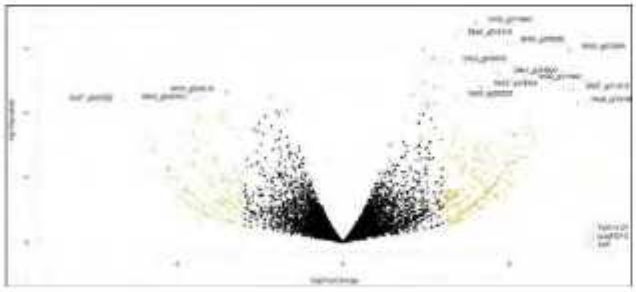


Fig. 1.4. Differentially expressed genes mapped on *Saccharum spontaneum* genome

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

MicroRNAs play a critical role in plant's adaptation towards many biotic and abiotic stresses. This project was initiated to unravel the profile of conserved and novel miRNA in response to red rot disease caused by fungus *Colletotrichum falcatum* in order to understand the small RNA-guided gene regulation red rot challenged sugarcane. During this year, two varieties of sugarcane, one red rot resistant genotype *viz.* BO 91 and one red rot susceptible genotype *viz.* CoJ 64 were planted in field as well as in pots and inoculated with *C. falcatum* pathotype Cf 08 at appropriate stage. Total RNA isolated from leaves of treated (T) and control (C) was subjected to small RNA library construction. QC passed purified Single end libraries of leaf small RNA were used for cluster generation and sequencing analysis using the Illumina NextSeq 500. Sequence data was checked for quality using fastp tool. The raw data read count was 2,56,19,126 for BO 91 (C), 3,03,58,312 for BO 91 (T), 2,20,77,764 for CoJ 64 (C) and 2,79,53,405 for CoJ 64 (T). Cleaned and filtered reads greater than 18nt in length were aligned to the ncRNA from RNA Central database and unaligned read count was 1,77,17,750 for BO 91 (C), 1,77,48,279 for BO 91 (T), 2,13,59,897 for CoJ 64 (C) and 1,74,04,832 for CoJ 64 (T). These unaligned reads were mapped to *Sorghum bicolor* reference genome and unmapped reads between the range 18 and 30 nt were used for prediction of miRNA according to the RNAfold algorithm using miRDeep2. Differentially expressed miRNAs were filtered out using a cut-off of adjusted p.value <0.05 and |log2 fold change| > 0 for known miRNA and p.value <0.05 and |log2 fold change| > 0 for novel miRNA. Comparative analysis showed 43 known and 46 novel differentially expressed miRNA (Fig. 1.5) having putative targets of protein binding transcription factors, transporter proteins, enzyme regulator activity, nucleic acid binding transcription factors, disease-resistance proteins and response to stimulus *etc.* Some miRNAs regulated many target genes in response to the red rot infection. qRT-PCR based validation of these differentially regulated miRNAs is underway.

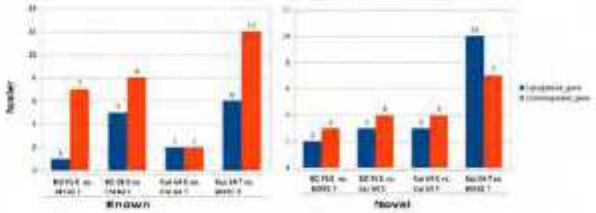


Fig. 1.5. Differential expression of Known and Novel miRNA in response to red rot inoculation

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

Under this project, the red rot resistant (BO 91) and susceptible (CoJ 64) cultivars of sugarcane were planted in field and crop was raised with four treatment sets to conduct the Proteomics experiment and standardize the sample preparation for LC-MS/MS proteomic expression analysis. Fresh cultures of *C. falcatum* pathotype Cf 08 were developed and their compatibility with crushed sugarcane stalk and leaves was checked.

Genomic selection-based accelerated breeding in sugarcane (*Saccharum* species complex)

Approx. 500 highly diverse sugarcane genotypes from different sugarcane research centres were chosen as training population. Their genotyping using 10 ISSR markers has completed. The marker data analyzed for population structure identification and a 'Training Population' of ~250 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. The GBS is being analysed for detection of SNPs in the training population. The prediction of appropriate Genomic Selection model and calculation of GEBV values for identification of superior clones has carried out.

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

One hundred and fifty three reference varieties of sugarcane are being maintained in DUS field. This reference collection includes all the identified, released and notified varieties from CVRC, varieties released from states and clones from Advanced Varietal Trials of AICRP(S) available with different research organizations working on sugarcane. DUS characters are recorded on 150 varieties in reference collection as per the DUS testing guidelines. Five 'New' and four Farmers' Varieties are presently under DUS Testing. DUS character based characterization has been initiated for the LG clones in the collection.

ICAR Seed Project (Seed Production in Agricultural Crops)

Total 8,200 quintal seed cane was produced and the total amount of seed sale was ₹ 16.29 lakh under ICAR Seed Project Revolving Fund. A grant of ₹ 9.25 lakh was received during 2020-21 from ICAR-IISS, Mau. During financial year 2020-21, approximately 8,000 quintals of seed cane will be produced from 12.0 ha area planted with newly released varieties for seed cane production (Table 1.4). New varieties included in the seed production are CoLk 14201, CoLk 14204, CoLk 12207 and CoLk 12209.

Under Seed Cane Awareness, seed of newly released varieties CoLk 14201, CoLk 14204 and others were distributed to farmers and several sugar mills. Field Days to popularize recently notified varieties *viz.*, CoLk 14201, CoLk 14204, CoLk 09204, CoLk 11206, CoLk 11203, CoLk 12207 and CoLk 12209 were organized at the Institute. Awareness for morphological identification of varieties with DUS characters under field condition was also taken-up with development staff and farmers.

Table 1.4. Sugarcane Seed Production at ICAR-IISR, Lucknow

Variety	Maturity	Approximate availability of Seed (q)
CoPk 05191	Early	800
CoLk 94184	Early	1000
CoLk 9709	Early	400
CoLk 09204	Mid-late	1000
CoLk 11206	Mid-late	900
CoLk 11203	Early	800
Co 0238	Early	1100
Co 0118	Early	700
Co 05011	Mid-late	100
CoLk 14201	Early	1000
Others (CoLk 12207 and CoLk 12209)		200
Total		8,000

Bihar Sugarcane Breeder Seed Production Programme at IISR Regional Station, Motipur, Bihar

Under BSPP, nearly 34,000 q breeder seed were produced and distributed to different agencies of Bihar. During 2020, 76 hectares area was planted for breeder seed production (Table 1.5). With an objective to increase the sugarcane seed production in Bihar, a MoU was signed in year 2020 between IISR and SID, Bihar.

Table 1.5 Breeder seed sugarcane production area

Breeder seed Production Centres	Area (ha)
IISR Regional Station, Motipur	4.0
HPCL, Sugauli	18.0
Jaishree Sugar Industries, Majhaulia	10.0
Vishnu Sugar Mills Ltd., Gopalganj	5.0
Tirupati Sugar Mills Ltd., Bagaha	14.0
New Swadeshi Sugar Mill, Narkatiaganj	15.0
Harinagar Sugar Mills, Harinagar	10.0
Total	**76.0**

CHAPTER 2

Natural Resource Management

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

The field experiment planted during 2019-20 crop season to enhance the crop productivity and profitability of autumn sugarcane planted in wide row spacing through high value intercrops. 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 and intercrops varieties were maize-VMH 150, garlic-G 323 and fenugreek-USK 120. The objectives were to find out the appropriate wide row spacing of sugarcane suitable for intercropping and to enhance system productivity and profitability and to assess the effect of various intercrops on soil quality parameters in sugarcane-based system and to identify compatible high value crops for intercropping in sugarcane.

Sugarcane growth and yield parameters

Wide row spacing remarkably influenced the growth parameters at different stages as it altered the crop geometry (Table 2.1). The sugarcane germination percentage was in the range of 35.92 to 45.83%, however non-significant. Numerically higher tillers and shoot population of sugarcane was recorded under the treatment sugarcane at 150 cm row spacing + garlic intercropping (149.63 thousand/ha at 90 days after planting- DAP), shoot count (137.41 thousand/ha at 120 DAP) as compared to sugarcane sole (90 cm row spacing) the conventional planting (125.18 thousand/ha at 90 DAP and 112.04 thousand/ha at 120 DAP, respectively). The maximum plant height was recorded when sugarcane was intercropped with different high value intercrops, except maize intercrop under three wide row spacings (90, 120, 150 cm). The highest plant height of sugarcane was at 120 cm row spacing + fenugreek intercropping (198.2 cm at 120 DAP) and sugarcane at 120 cm row spacing + garlic intercropping (277.5 cm at 180 DAP), then maize intercrops under different wide row spacing. The wide

Table 2.1. Effect of sugarcane on number of millable canes, yield and cane equivalent yield

	Treatment	Number of millable canes (000/ha)	Cane yield (t/ha)	Cane equivalent yield (t/ha)
T1	Sugarcane sole at 90 cm spacing	100.463	146.48	146.48
T2	Sugarcane sole at 120 cm spacing	83.334	121.78	121.78
T3	Sugarcane sole at 150 cm spacing	68.556	98.77	98.77
T4	Sugarcane at 90 cm spacing + Garlic (1:3)	95.093	140.74	350.70
T5	Sugarcane at 120 cm spacing + Garlic (1:5)	64.000	89.77	327.51
T6	Sugarcane at 150 cm spacing + Garlic (1:7)	76.333	109.44	331.32
T7	Sugarcane at 90 cm spacing + Fenugreek (1:2)	93.518	137.22	170.50
T8	Sugarcane at 120 cm spacing + Fenugreek (1:3)	77.000	117.66	152.33
T9	Sugarcane at 150 cm spacing + Fenugreek (1:4)	72.556	106.67	142.68
T10	Sugarcane at 90 cm spacing + Maize (green cobs -1:1)	91.204	111.94	262.10
T11	Sugarcane at 120 cm spacing + Maize (green cobs -1:2)	75.445	115.66	269.51
T12	Sugarcane at 150 cm spacing + Maize (green cobs -1:3)	88.778	122.55	305.05
	SEm ±	6.69	11.18	
	CD (P=0.05)	19.77	33.01	
	C.V. (%)	14.11	16.38	

row planted sugarcane (150 cm row spacing) grew rapidly due to availability of light, space and moisture. The lowest tiller and shoot population were observed when sugarcane was intercropped with maize for green cobs. It indicates from the study that sugarcane intercropped with maize has competition for nutrients, space as well as sunlight which affected the growth of sugarcane. The number of millable cane (NMC) and sugarcane yield were significantly higher in 90 cm and 120 cm row spacing (NMC-100.46 thousand/ha, cane yield- 146.48 t/ha and 83.33 thousand/ha, 121.78 t/ha, respectively) in sugarcane sole crop (on par) as compared to 150 cm row spacing (68.56 thousand/ha, 98.77 t/ha). Higher cane yield in 90 cm row spacing was found in sugarcane + garlic (140.74 t/ha), sugarcane + fenugreek (137.22 t/ha) and in 150 cm row spacing of sugarcane + maize (122.55 t/ha) intercropping system (Table 2.2).

Yield performance of component intercrops and their combined productivity

The yield in intercropping system was converted into Cane Equivalent Yield (CEY) for better comparison of different sugarcane based intercropping system (Table 2.2). Adopting wider row spacing of 150 cm and 120 cm reduced the mean cane yield (109.36 t/ha) by 22.6% and (111.22 t/ha) by 20.6%, respectively, as compared to 90 cm row spacing (134.09 t/ha). Increased planting density of intercrops from lower population (90 cm row spacing) to higher population level increased the mean yields of garlic (140.48 q/ha by 13.2%) in 120 cm row spacing and 131.11 q/ha by 5.7 % in 150 cm row spacing compared to 90 cm row spacing. Similarly, the mean green leaves yield of fenugreek (112.69 q/ha, 4.2%) in 120 cm and (117.04 q/ha, 8.2%) in 150 cm row spacing than 90 cm row spacing (108.15 q/ha). The mean yield of maize green cobs (1,66,667/ha, 2.5%) in 120 cm and (1,97,704/ha, 21.5 %) in 150 cm row spacing than 90 cm row spacing (1,62,666/ha). This indicates that competition between the component intercrops was more in 90 cm compared to wide row spaced sugarcane.

Intercropping system increased the total productivity (CEY) as compared to sole sugarcane. Sugarcane + garlic intercropping in autumn planting produced the highest cane equivalent yield (CEY 350.7 t/ha) followed by sugarcane + maize intercropping the next best at 150 cm row spacing (CEY 305.05 t/ha).

Effect of sugarcane on yield of intercrops

The intercrops were taken in between rows' gap of sugarcane under three wide row spacings (90, 120, 150 cm). Among different intercrops, autumn sugarcane at 120 cm row spacing + garlic (1:5 ratio) produced maximum yield (140.48 q/ha) and fetched the highest gross income of ₹ 7,72,622/ha. The next best treatment was observed with sugarcane at 150 cm row spacing + maize green cobs (1:3 ratio), 1.97 lakh green cobs/ha and gross income ₹ 5,93,111/ha. The other intercrops fenugreek produced maximum green leaves (117.04 q/ha) under sugarcane at 150 cm row spacing + fenugreek (1:4 ratio) and gross income of ₹ 1,17,037/ha found highly remunerative. It indicates that autumn sugarcane-based intercropping shall hold promise in doubling the net farmers income sugarcane.

Table 2.2. Yield performance of the component intercrops and their combined productivity under autumn sugarcane planted in wide row spacing

Sugarcane based inter-cropping system	Cane yield (t/ha)				Intercrop yield (q/ha, No. of green cobs/ha)				Cane equivalent yield (t/ha)			
	90 cm	120 cm	150 cm	Mean	90 cm	120 cm	150 cm	Mean	90 cm	120 cm	150 cm	Mean
Sugarcane sole	146.48	121.78	98.77	122.34	-	-	-	-	146.48	121.78	98.77	122.34
Sugarcane + garlic	140.74	89.77	109.44	113.32	124.07	140.48	131.11	131.89	350.70	327.51	331.32	336.51
Sugarcane + fenugreek	137.22	117.66	106.67	120.52	108.15	112.69	117.04	112.63	170.50	152.33	142.68	155.17
Sugarcane + maize	111.94	115.66	122.55	116.72	162666	*166667	*197704	*175679	262.10	269.51	305.05	278.89
Mean	134.09	111.22	109.36		-	-	-	-	232.27	217.78	219.46	

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

A field experiment was initiated with the objective to identify the most remunerative sugarcane based cropping system in sub-tropical India. During *Rabi* season, 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. Out of component crops, three crops (Wheat, *Stevia* and Wild marigold) were harvested and succeeding spring sugarcane were planted in the field during summer season. The highest wheat equivalent yield (95.5 q/ha) of wild marigold was recorded under *Tulsi*-Wild Marigold (Two cut) - Sugarcane (spring) - Sugarcane ratoon-Mint cropping sequence. Significant differences in succeeding spring planted sugarcanes as per sequence were recorded for growth and yield attributing characters due to different cropping sequence.

Developing sugarcane based integrated farming system models for small farm 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 by adapting principles of sustainable agriculture. Keeping above points, ICAR-IISR, Lucknow planned and executed the sugarcane based Integrated Farming System on its research farm on long term basis. The experiment consisted of sugarcane based Integrated Farming System including different components of Agriculture (Sugarcane) *viz.* horticulture (Vegetables, banana, papaya, and boundary planting of *karonda*-Christ's thorn), Backyard Poultry, Fisheries, Vermicompost, Apiculture, Mushroom with the objectives to develop sugarcane based integrated farming system models for marginal and small farm in sub-tropics India. Allocation of farm land to each component were kept in such a way that may fullfill the minimum essential annual requirements of food, vegetables, fish, egg. chicken, honey, pickles, mushroom *etc.*, of a household having seven family members and overall improvement in their livelihood. Impacts of different treatments on yield, profitability, employment generation, product (waste) recycling parameters were observed. The most profitable enterprise was sugarcane sole, or sugarcane + fish + backyard poultry + vegetables + vermicompost + horticultural crops.

Different enterprises were integrated with sugarcane-based system mainly autumn and spring planted crop. Total four sets of modules were evaluated with two main sugarcane growing seasons. The main recommendations obtained are mentioned below:

(A) Autumn planted Sugarcane based IFS:

1. Sugarcane alone-₹2,59,200/ha. net income
2. Sugarcane + Vegetables (Garlic, Fenugreek, Coriander, Tomato, Cauliflower, Spinach, Carrot, Faba bean, Onion) net income ₹3,24,102 ha.
3. Sugarcane + Vegetables (Garlic, Fenugreek, Coriander, Tomato, Cauliflower, Spinach, Carrot, Faba bean, Onion) + Horticultural Crop (Banana) +Backyard Poultry (Breed-*Asheel, Nirbheek, Kadaknath*) net income ₹3,56,862 / ha.
4. Sugarcane + Vegetables (Garlic, Fenugreek, Coriander, Tomato, Cauliflower, Spinach, Carrot, Faba bean, Onion) + Horticultural Crop (*Karonda* boundary plantation) +Backyard Poultry (*Asheel, Nirbheek, Kadaknath*) + Fisheries (*Rohu, Catla, Nain*) + Vermicompost (*Eisenia fetida*) + Apiculture + Mushroom net income ₹4,62,412 /ha.

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) + Fisheries (Rohu, Catla, Nain) + Vermicompost (*Erucina fotida*)+ Apiculture + Mushroom, net income ₹ 4,62,412/ha. and additional income of ₹2,03,212/ha (Table 2.3).

Table 2.3. Productivity and profitability of different components of the cropping/farming system integrated with sugarcane (Autumn planted sugarcane)

Sr. No.	Cropping/Farming systems	Cost of production (₹/ha.)	Gross income (₹/ha.)	Net income (₹/ha.)	Income from component crop/ enterprise (₹/ha.) or enterprises /unit
1.	Sugarcane (Sole) Cv. CoLk 09204	1,65,000	4,24,200	2,59,200	-
2.	Sugarcane + Vegetables (including horti. crops) throughout year	1,85,450	5,09,552	3,24,102	64,902
3.	Sugarcane + Vegetables (including horti. crops) throughout year + Backyard poultry	1,95,450	5,52,312	3,56,862	32,760
4.	Sugarcane + Vegetables throughout year (including horti. crops) + Backyard poultry + Fisheries + Vermicompost + Apiculture + Mushroom	2,03,900	6,66,312	4,62,412	1,05,550

(B) Spring planted Sugarcane based IFS:

1. Sugarcane alone- net income ₹2,55,800/ha.
2. Sugarcane + Vegetables (Bottle gourd, Sponge gourd, Tomato, Brinjal, Pumpkin, Onion,) net income ₹3,25,040 / ha.
3. Sugarcane + Vegetables (Bottle gourd, Sponge gourd, Tomato, Brinjal, Pumpkin, Onion) + Horticultural Crop (Banana) + Backyard Poultry (Breed- *Asheel, Nirbheek, Kadaknath, Quail*) net income of ₹3,57,800/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 (*Eisenia fetida*) + Apiculture + Mushroom net income of ₹4,53,350/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*) + Fisheries (*Rohu, Catla, Nain*) + Vermicompost (*Erucina fotida*) + Mushroom fetched net income of ₹4,53,350/ha fetching additional income of ₹1,97,550/ha (Table 2.4).

It was felt that inclusion of other farming components *viz*; Dairy (Cow) in this farming system may provide further additional income besides making the system more productive, profitable and sustainable. Therefore, an action was initiated for effective and efficient incorporation of these enterprises from 2020 onward.

Varieties /breeds of crops and enterprises taken in the systems-Different crops/animals and their varieties/species used in this systems were Sugarcane- CoPK 05191, CoLK 09204; Vegetables- Bottle gourd (*Kashi Ganga*), Spong gourd (*Kashi Khushi*), Tomato (*Kashi Ayan*), Brinjal (*Kashi Uttam*), Pumpkin (*Kashi Harit*), Green chili (*Kashi Anmol*), Coriander (*Kashmini*), Faba bean (Cherry), Okra (*Kashi Kranti*); Fruits- Banana (G-9), Papaya (Pusa Dwarf); Poultry Breed- *Ashil, Kadaknath, Nirbhik;* Fish Breed-*Rohu, Catla, Nain;* Verm *Spp- Eisenia fetida,* Apiculture- *Aphis mangifera.*

The results indicated that autumn sugarcane based integrated farming system as Sugarcane + Vegetables (Garlic, Fenugreek, Coriander, Tomato, Cauliflower, Spinach, Carrot, Fababean, Onion) + Horticultural Crop (*Karonda* boundary plantation + Papaya + Banana) +Backyard Poultry (Breed, *Asheel, Nirbheek, Kadaknath, Quail*) + Fisheries (*Rohu, Catla, Nain*) + Vermicompost (*Erucina fetida*) + Apiculture+ Mushroom fetched net income of ₹4,62,412/ha. (Table 2.3).

The results indicated that spring sugarcane based integrated farming system as 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 ₹4,53,350/ ha, fetching additional income of ₹1,97,550/ha (Table 2.4).

Table 2.4. Productivity and profitability of different components of the cropping/farming system integrated with sugarcane (Spring planted sugarcane)

Sr. No.	Cropping/Farming systems	Cost of production (₹/ha)	Gross income (₹ /ha)	Net income (₹/ha)	Income from component crop/ enterprise (₹/ha) or enterprises /unit
1.	Sugarcane (Sole) CoPk 05191	1,60,000	4,15,800	2,55,800	-
2.	Sugarcane + Vegetables (including horti. crops) throughout year	1,72,480	4,97,520	3,25,040	69,240
3.	Sugarcane + Vegetables (including horti. crops) throughout year + Backyard poultry	1,82,480	5,40,280	3,57,800	32,760
4.	Sugarcane + Vegetables throughout year (including horti. crops) + Backyard poultry + Fisheries + Vermicompost + Apiculture + Mushroom	1,90,930	6,54,280	4,53,350	95,550

Rate of different commodities and produce as per prevailing market rates/mandi rates.

In nutshell, in autumn planted sugarcane based Integrated Farming System, the farming systems is employing and also hold promise in increasing the net income, employment generation of seven farm family member, throughout the year as compared to sole sugarcane.

Varieties/breeds of crops and enterprises taken in the systems-Different crops/animals and there varieties/species used in this systems were Sugarcane-CoPK 05191, CoLk 9204; Vegetables- Bottle gourd (*Kashi Ganga*), Spong gourd (*Kashi Khushi*), Tomato (*Kashi Ayan*), Brinjal (*Kashi Uttam*), Pumpkin (*Kashi Harit*), Green chili (*Kashi Anmol*), Coriander (*Kashmini*), Fababean (Cherry), Okra (*Kashi Kranti*); Fruits- Banana (G-9), Papaya (Pusa Dwarf); Poultry Breed- *Ashil, Kadaknath, Nirbhik*; Fish Breed-*Rohu, Catla, Nain*; Verm *Spp- Erucina fotida.*

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

Conservation Agriculture (CA) in Sugarcane Based Production System

Field experiment to assess 'the effect of conservation agriculture practices on the productivity and profitability of sugarcane-based production system and soil quality parameters' was initiated with sowing of dry direct seeded rice (DSR) followed by sowing of wheat and planting of sugarcane followed by sugarcane ratoon. The experiment comprised of 24 treatments in 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. Findings of first year experiment revealed that (Table 2.5) tillage practice significantly influenced the tiller number at 180 day after initiation of sugarcane ratoon, NMC and yield of sugarcane ratoon. Crop residue management (retention/ incorporation of crop residue of previous crop) treatment recorded increase in ratoon cane yield tune to the of 20.88% as compared to without crop residue management (64.36 t/ha). However, conventional tillage practice enhanced ratoon cane productivity @ 0.57% higher over the zero tillage (70.87 t/ha). All the doses of nitrogen were found at par with respect to growth and yields of ratoon cane. Wheat was sown after harvesting of sugarcane ratoon.

In experiment, sugarcane crop was planted after harvest of wheat. Data depicted in Table 2.6 evidenced that tillage practice significantly influenced the tiller number at 90 and 180 day 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 cane yield tune of 14.85% over without crop residue management (66.62 t/ha). Crop residue management (retention/

Table 2.5. Effect of tillage and management practices on growth, yield and yield attributes of sugarcane ratoon

Treatment	Shoot count ('00000/ha)		NMC ('000/ ha)	Cane length (cm)	Cane diameter (cm)	Cane yield (t/ha)
	45 DAI	180 DAI				
Conventional tillage with residue retention	1.23	2.14	114.9	253.2	2.01	78.05
Conventional tillage without residue retention	1.19	1.95	94.5	236.7	1.97	64.50
Zero tillage with residue retention	1.25	2.12	113.5	252.3	2.00	77.53
Zero tillage without residue retention	1.19	1.94	93.9	235.9	1.96	64.21
CD (P=0.05)	NS	0.13	10.93	9.24	NS	6.06
With Brown manuring	1.22	2.05	104.1	244.5	1.99	70.40
Without Brown manuring	1.22	2.02	104.3	244.6	1.98	71.75
CD (P=0.05)	NS	NS	NS	NS	NS	NS
75% of Recommended Dose of	1.13	1.98	101.8	242.6	1.97	69.34
Nitrogen (RDN)	1.24	2.06	104.8	243.9	1.99	71.03
125% of RDN	1.27	2.07	106.1	247.0	2.00	72.86
CD (P=0.05)	NS	NS	1.45	3.41	NS	1.44

Table 2.6. Effect of tillage and management practices on growth, yield and yield attributes of sugarcane

Treatment	Tiller count ('000/ha)		NMC ('000/ ha)	Cane length (cm)	Cane diameter (cm)	Cane yield (t/ha)
	90 DAP	120 DAP				
Conventional tillage with residue retention	97.56	103.86	94.04	298.28	2.87	77.03
Conventional tillage without residue retention	87.84	94.44	85.06	269.78	2.64	67.25
Zero tillage with residue retention	95.19	102.71	92.92	295.45	2.89	75.99
Zero tillage without residue retention	85.70	93.48	84.65	267.89	2.65	65.98
CD(P=0.05)	7.85	7.5	7.45	11.91	0.18	4.36
With Brown manuring	92.60	99.64	89.69	283.08	2.77	71.93
Without Brown manuring	90.55	97.6	88.65	282.61	2.76	71.19
CD (P=0.05)	NS	NS	NS	NS	NS	NS
75 % of Recommended Dose of	87.29	95.14	85.92	274.17	2.66	67.26
Nitrogen (RDN)	92.33	99.16	89.88	283.63	2.78	72.61
125% of RDN	95.1	101.57	91.70	290.75	2.85	74.82
CD (P=0.05)	3.67	4.34	4.59	11.01	0.15	2.33

incorporation of crop residue of rice and wheat) treatment recorded increase in tiller production in sugarcane tune of 11.08 & 9.93% over without crop residue management at 90 & 120 DAP, respectively.

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 to assess the effect of split application of NPK under drip fertigation on sugarcane plant and ratoon productivity. The experiment comprising seven treatments was laid out in RBD with four replications. The soil of the experimental field was low in O.C and medium in NPK. Paired planting (120:30 cm) of sugarcane variety CoLk 11206 was done in trenches. Plant cane harvesting was done in first week of Feb, and was left for 1st ratoon crop initiation.

NMC count (000/ha) ranged from 66.40 to 121.66 in different treatments. Higher NMC, per cane weight

and cane yield were recorded in the treatments where 100% NPK were given in different split. Cane yield tonne/ ha ranged from 51.40 to 102.36 under different treatments. Application of 100% RDF of NPK through drip fertigation gave 72% higher ratoon cane yield (97 t/ha) over application of same doses of fertilizer by conventional methods (56.39 t/ha). The 25% reduction in RDF of NPK under drip fertigation gave statistically higher cane yield as it was reported under 100% RDF of NPK in conventional methods. Statistically similar cane yield was reported between 50% RDF through drip and conventional methods. The highest value (102.36 tonne/ha) was reported in T7 while the lowest cane yield was recorded in T6 (51.40 tonne/ha) treatment. There was a non-significant improvement in cane yield was observed in T7 over T4, wherein 110% RDF of NPK and RDF of NPK, respectively was delivered (Table 2.7). On an average under drip fertigation, the weed biomass was less (25%) than conventional method where entire field was wetted in each irrigation. Irrigation requirement 1035.6 mm. Out of which 60% was given in drip (40% saving).

Brix per cent ranged from 19.17 (T6) to 20.12 (T4). There was significant improvement in brix per cent in T4 & T7 treatments over conventional (T1) and 50% NPK (T6) treatments. However, the T4 and T7 were significantly at par. Similarly, sucrose per cent was reported higher under T4 (18.23%) followed by T7 (17.89%), T3, T2, T1, T5 and T6. The T4 & T7 being significantly at par but proved significantly superior over rest of the treatments as far as sucrose per cent was concerned. The other treatments did not differ significantly among themselves. The purity per cent in T4 was significantly higher over all the treatments except T7. There was a overall improvement in initial O.C%, SMBC and SMBN in all the treatments but extent of increase of these parameters were reported higher in T4 and T7 treatments where 100% and 110% RDF of NPK was applied through drip) over conventional method (Table 2.8).

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

Ratoon initiated as per date of planting and it was started in February followed by March, April and May. Observations on these four dates of ratoon initiation were taken as per standard plan. The data on tiller population showed that February initiated ratoon recorded the highest no. of tillers at 180, 210 and 240 days after ratoon

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

Treatments No	Treatment	NMC/ ha (000)	Per cane wt (kg)	Yield (t/ha)
T1	Conventional	76.02	0.73	56.39
T2	N through drip + PK basal	99.00	0.78	78.06
T3	NP drip + K basal	105.00	0.80	83.50
T4	100% NPK drip	114.40	0.818	97.00
T5	75%NPK drip	91.00	0.76	70.36
T6	50% NPK drip	66.40	0.74	51.40
T7	100% NPK through drip*	121.66	0.86	102.36
		13.57	0.068	7.03

* 10 % additional NPK was applied

Table 2.8: Quality parameters as influenced by different treatments

Treatments	Brix (%)	Sucrose (%)	Purity	O.C. (%)	SMBC	SMBN
Conventional	19.51	17.07	87.44	0.32	146	4.1
N through drip + PK basal	19.57	17.12	87.50	0.34	189	4.23
NP drip+ K basal	19.55	17.25	88.24	0.36	178	4.18
100% NPK drip	20.12	18.23	90.60	0.37	220	4.35
75% NPK drip	19.56	16.95	86.64	0.35	150	4.15
50% NPK drip	19.17	16.54	86.31	0.30	136	3.88
100% NPK through drip	20.10	17.89	89	0.36	230	4.36
C.D. at 5%	0.61	0.74	1.61	0.012	6.06	0.21
Initial	-	-	-	0.28	118	3.69

initiation (DARI). However, it was significantly higher than April and May initiated ratoon and was statistically at par with March started ratoon. Whereas March, April and May initiated ratoon crop was at par among them. Tiller count in February initiated ratoon recorded at 210 DARI showed significantly higher tiller count than remaining treatments while at 240 days stage was at par with March crop. March initiated ratoon crop gave statistically higher number of plant population than April and May initiated crop at 210 and 240 DARI. Similarly, February initiated ratoon recorded statistically higher number of plant tillers than remaining three dates of ratoon inifiation. March and April initiated ratoon were at par among themselves. The effect of applied nutrients based on STCR observation recorded higher no. of tillers in treatment NPK through using STCR without IPNS, but it was non-significant at 180 and 240 DARI, whereas tiller population recorded in the treatment-NPK through using STCR without IPNS was significantly higher than recommended dose of NPK and similar with NPK through using STCR with IPNS at 210 DARI. Initially, number of tillers was higher and at later stage, reduced. The data recorded on shoots count showed that the maximum shoots were recorded in February initiated crop and was statistically superior to rest of the treatments whereas March and April initiated dates were at par (Table 2.9). The lowest number of shoots was found in May initiated crop. In the sub-plot treatment, recommended dose of fertilizer gave least number of shoot count and the highest number of shoots were recorded in the treatment NPK through using STCR with IPNS but it was non-significant with other treatments.

Single cane parameter as affected by days of ratoon initiation and STCR based nutrient application

Almost all the plant growth parameters are affected by nutrient and planting time. The observations recorded on single cane parameter revealed that the highest length (2.20 m), girth (23.60 cm) and per cane weight (0.944 kg) was found in February initiated ratoon followed by rest of the treatment.(Table 2.10) In the February crop, the cane length was significantly higher than April and May initiated ratoon crop and statistically similar with March initiated crop. The crop in April and May was at par with each other. First and second month-initiated ratoon crop thickness was significantly higher than April and May initiated crop while it was at par with March crop. Similarly, February crop gave statistically superior cane weight than weight observed in April and May crop whereas it was at par with March crop. In sub-plot, the highest cane length (2.08 m) was recorded in the treatment NPK through using STCR with IPNS followed by NPK through using STCR without IPNS and recommended dose of fertilizer. Slightly better cane thickness (22.94 mm) was measured in the treatment NPK through using STCR without IPNS than remaining treatments though it was statistically non-significant. (Table 2.10). Single cane weight was directly related to length and thickness of the cane. The single cane weight achieved in February started ratoon crops was statistically superior over crop begins in April and May while it was at par with March initiated crop. Similarly, NPK through using STCR with IPNS treatment gave slightly

Table 2.9. Effect of days of ratoon initiation and STCR based nutrient application on tiller population and shoot count

Treatment	Tillers count /ha			Shoot count/ha
	180 DARI	210 DARI	240 DARI	
Main plot (Month of planting)				
February	175740.5	174555.6	133185.2	124925.9
March	169518.8	170925.9	131370.4	117074.1
April	159296.3	165555.6	126740.8	116481.3
May	162481.9	159407.4	125037.1	99222.2
SE(m)	2962.2	2319.5	1326.2	4519.6
CD (p=0.05)	10449.9	8182.7	4678.6	15943.9
Sub-plot				
Recommended NPK	158916.7	162527.8	123333.3	109444.5
NPK through using STCR without IPNS	165638.9	173416.7	131777.8	116055.6
NPK through using STCR with IPNS	170888.9	166888.9	132138.9	117777.8
SE (m)	5204.5	2773.6	2627.6	3283.5
CD (p=0.05)	NS	8387.1	NS	NS

DARI (Days after ratoon initiation)

Table 2.10. Effect of days of ratoon initiation and STCR based nutrient application on single cane parameter

Main plot (Date of planting)	Length (m)	Girth (mm)	Weight (kg)
February	2.20	23.60	0.944
March	2.11	23.27	0.889
April	1.92	21.40	0.733
May	1.74	20.94	0.600
SE(m)	0.06	0.48	0.041
CD (p=0.05)	0.20	1.69	0.145
Sub-plot			
Recommended NPK	1.95	22.17	0.758
NPK through using STCR without IPNS	2.01	22.94	0.867
NPK through using STCR with IPNS	2.08	21.80	0.750
SE(m)	0.03	0.44	0.092
CD (p=0.05)	NS	NS	NS

less single cane weight than recommended dose of fertilizer and NPK through using STCR without IPNS treatment. Though all three treatments were statistically at par.

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

A 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 ratooning system. The experiment comprising of fourteen treatments in combination with three nutrients management levels and four levels of microbial consortia along with two controls was laid out in RBD with three replications with plant crop using sugarcane variety *cv.* CoLk 09204. Data on germination, tillers, shoots, number of millable cane (NMC) and cane yield were recorded and found non-significant variations showing uniform plant crop over all plots for better initiation of first ratoon starting with March, 2020. The plant stand was uniformly maintained resulting in higher cane yield ranged from 100-120 t/ha over the experiment. Microbial cultures of different nutrients have been isolated, characterized and identified. All the microbial cultures have been identified and tested for their compatibility with no negative response. These potential microbial cultures are for N- *Gluconacetobacter diazotrophicus* (NB69) , P – *Pseudomonas flouresens (PSB 28)*, K - *Enterobacter cloacae (KSB9)*, Zn - *Acinetobacter calcoaceticus (ZSB18) and* S - *Pseudomonas nitroreducens (SOB45)* have been applied at optimum moisture in respective treatments in first ratoon crop.

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 with experiment was initiated (autumn planted sugarcane) and second set was initiated on (spring planted sugarcane) with three moisture regime and three fertilizer doses in strip-plot design with three replications. The results revealed that growth characters *viz.*, number of tillers, shoots and plants were affected significantly with the alteration of moisture regime at both the seasons but autumn planted sugarcane recorded the highest tillers and shoot counts and plant height than the spring planted sugarcane. Among the moisture regimes, water logging achieved significantly higher growth characters 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 tillers, 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 2.11). The highest sugarcane yield was recorded under autumn planted sugarcane than spring planted except water logging regime. The water logging conditions significantly increased cane yield over optimal and sub-optimal conditions at both the season, and increase was 6.41 and 14.3% in autumn planted cane and 10.6 and 31.2% 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 seasons. Application of mineral fertilizers based on STCR increased cane yield in the tune of 9.74 and 24.3% at autumn and 10.3 and 22.6% at spring planted crop over RDF and FP, respectively.

Table 2.11. Effect of moisture regime on growth, yield attributers and yield of autumn and spring planted sugarcane

Treatment	Tillers (10⁵/ha)		Shoot (10⁵/ha)		Plant height (m)		Cane girth (cm/plant)		Cane weight (kg/plant)		NMC (10⁵/ha)		Yield (t/ha)	
	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring
Moisture condition														
Sub-optimum	142.4	121.6	103.8	102.1	2.71	2.50	2.26	2.27	1.03	0.98	102.7	99.1	107.5	95.1
Optimum	156.5	144.0	115.8	110.6	2.85	2.65	2.36	2.33	1.12	1.13	110.2	110.0	115.5	112.8
Water logging	165.0	155.3	123.2	120.8	2.97	2.74	2.45	2.41	1.22	1.22	118.5	117.7	122.9	124.8
CD (P=0.05)	8.43	7.58	5.99	4.92	0.11	0.11	0.08	0.06	0.94	0.05	7.14	7.40	7.18	8.04
Fertilizers dose														
FP	145.3	131.0	101.9	101.1	2.73	2.47	2.24	2.25	1.00	1.03	102.0	101.8	102.4	99.7
RDF	154.1	140.0	111.7	110.7	2.84	2.66	2.35	2.35	1.14	1.10	110.7	109.1	116.0	110.8
STCR	164.6	149.7	122.2	121.6	2.96	2.75	2.43	2.43	1.24	1.19	118.7	116.2	127.3	122.2
CD (P=0.05)	8.34	5.83	7.00	4.72	0.10	0.078	0.12	0.09	0.58	0.034	10.31	4.25	9.81	6.91
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

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

Development of scientific aids for site specific nutrient management through variable mapping of soil properties in sugarcane growing soils was implemented with objectives to characterize the variability in soil properties, relationship among them and identify the most contributing parameters in soil quality. The other objectives of the project were 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 research work was initiated from the research farm of ICAR-IISR, Lucknow. The boundary lines of research farm of ICAR-IISR, Lucknow were digitized by geo-referencing for development of soil properties maps (Fig. 2.1). The legacy soil data of research farm were examined and 100 field soil data were found suitable for development of soil properties maps. The pH and electrical conductivity of the study area varied from 7.57 to 8.22 and 0.14 to 0.25 dS/m, with average values of 7.94 and 0.20 dS/m, respectively. Soil organic carbon (SOC) content varied from 0.29 to 0.84%, available nitrogen from 219.5 to 335.6 kg/ha, phosphorus from 14.6 to 53.7 kg/ha and potassium from 197.5 to 350.3 kg/ha with mean values of 0.53%, 258.3, 30.1 and 248.9 kg/ha, respectively. SOC was positively correlated with available N (0.97) and P_2O_5 (0.42). However, pH was negatively correlated with P_2O_5 (-0.47). The soil properties of pH, electrical conductivity, soil organic carbon, available nitrogen, phosphorus and potassium were analyzed through geo-statistical analysis for the development of soil maps based on the best fit semivariogram models.

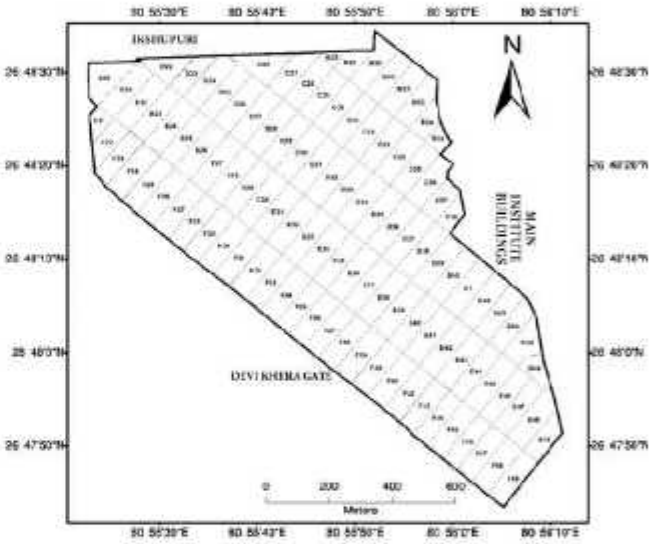


Fig. 2.1. Geo-referenced map of Research Farm, ICAR-IISR, Lucknow

Semivariogram model exponential was found the best fitted model for the mapping of soil pH. J-Bessel semivariogram model was found the best fit for the mapping of electrical conductivity and K-Bessel for soil organic carbon. K-Bessel, Stable and Gaussian semivariogram models were found the best fit for the spatial mapping of available nitrogen, phosphorus and potash. Based on the best fit semivariogram models of various soil properties, spatial distribution maps of study area have been developed for soil pH, electrical conductivity, soil organic carbon, available nitrogen, phosphorus and potassium.

Grid based 208 geo-referenced soil samples were collected from the Research Farm of ICAR-Indian Institute of Sugarcane Research, Lucknow to study the present status of soil properties. Out of the 208 soil samples collected, 104 samples were from the surface

soil (0-15 cm) and 104 were from the sub-surface soil (15-30 cm). The soil analysis report revealed that the highest soil pH (8.18) was observed in C Block and minimum was recorded in F Block (7.78). Electrical conductivity was found in the neutral range in entire research farm. The average status of soil organic carbon in the farm was medium (0.50%). The available nitrogen was found in deficient range (<280 kg/ha), however, available phosphorus and potash were found in medium status. The studied micronutrients were found above to their critical limits. In general, soil pH of the sub-surface was found higher than the surface soil, however, values of all other studied soil properties were found lower as compared to the surface soils.

Assessment of climate change impact on sugarcane productivity

The long term (1956 to 2019) data of weather parameters *viz.* temperature (minimum and maximum), relative humidity (morning and afternoon), rainfall, evaporation rate, wind speed and bright sunshine hours (BSS) were studied at ICAR-Indian Institute of Sugarcane Research, Lucknow. The minimum temperature variation during the different month of year varied from 7.27°C in the month of January to 26.59°C in the month of June. The long-term minimum temperature of February, March and December showed significantly increasing trend at the rate of 0.29, 0.26 and 0.21°C, per decade, respectively. The maximum temperature minimum value was recorded in January (21.76°C) and maximum value in May (39.23°C). It showed decreasing trend in the months of January (-0.37°C/decade) and May (-0.32°C/decade), however, increasing trend was recorded in August (0.12°C/decade). The relative humidity in morning showed significantly increasing trends during all the months of year except August. The increasing trend in the morning relative humidity varied from 0.38% (December) to 2.58% (May) per decade. The similar increasing trend in relative humidity of afternoon was observed during January to May and further from November to December. The minimum significantly increasing trend in afternoon relative humidity was recorded 0.80% per decade in April and significantly maximum decadal increasing trend was recorded 2.32% in February. The long-term monthly average of rainfall indicated that the highest monthly rainfall was recorded in July (268.14 mm) and the minimum rainfall in November (4.14 mm). The rainfall showed significantly increasing trend in February (0.97 mm/decade), however, declining trend was recorded in August (17.28 mm/ decade). The data of evaporation rate and wind speed were considered from 1989 to 2019. The average monthly evaporation rate varied from 1.59 mm/day (December) to 8.40 mm/day (May). It showed significantly declining trend from January to May and further from November to December. The average wind speed during the different months varied from 1.48 km/hr (November) to 4.82 km/hr (April). The declining trend was also found in the wind speed from January to May and from July to September. The significantly declining trend in the bright sunshine hours was recorded from January to April, July, and September and further from November to December.

The weather parameters of ICAR-Sugarcane Breeding Institute, Coimbatore; Regional Research Station, Faridkot; Sugarcane Research Institute, Pusa; Regional Sugarcane and Jaggery Research Station, Kolhapur and Sugarcane Research Station, Nayagarh were studied for monthly seasonal and annual level of climate change. The long-term average annual maximum rainfall (1576.2 mm) was recorded at Nayagarh and minimum average annual rainfall (502.4 mm) was recorded at Faridkot (Fig. 2.2). The minimum and maximum temperatures are another important weather parameter in sugarcane production. The minimum temperature showed significantly increasing trend in March at Faridkot, February to April at Kolhapur and December at Coimbatore. The maximum temperature showed significantly increasing trend in August to September at Faridkot, May at Kolhapur and in October at Coimbatore.

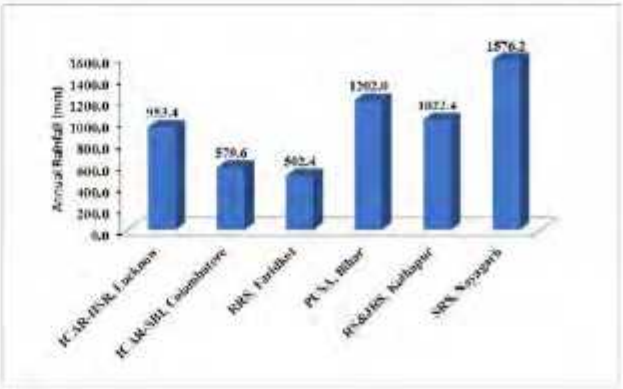


Fig. 2.2. Long-term average annual rainfall pattern at different sugarcane research centres

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

The experiment was conducted 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 06204. The data recorded on germination could not exert significant variations due to different treatments. The data recorded on tillering indicated significant variations among the treatments (Table 2.12). Though numerically the highest number of tillers at 90 and 120 DAP 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. The lowest values of tillers were recorded under control. Among different sources of silicon, bagasse ash and diatomaceous earth exhibited better response compared to foliar spray of potassium silicate on number of tillers/ha.

Total 120 soil samples were collected from IISR farm from the depth of 0-15 and 15-30 cm. Out of these, 76 soil samples were analysed to assess the nutrient status of soil (Table 2.13). The soil pH varied from 7.20

Table 2.12. Number of tillers as influenced by source and dose of silicon

Treatment	Germination (%)	Tiller no. (000/ha)	
		90 DAP	120 DAP
Control (No silicon application)	36.14	76.25	89.55
Silicon @ 200 kg/ha through bagasse ash	37.02	83.93	96.85
Silicon @ 400 kg/ha through bagasse ash	38.17	89.46	104.71
Silicon @ 600 kg/ha through bagasse ash,	38.90	90.31	106.26
Silicon @ 800 kg/ha through bagasse ash	38.83	91.80	107.26
Silicon @ 200 kg/ha through diatomaceous earth	38.0	84.30	97.07
Silicon @ 400 kg/ha through diatomaceous earth	38.0	90.18	105.04
Silicon @ 600 kg/ha through diatomaceous earth	38.17	91.34	106.3
Silicon @ 800 kg/ha through diatomaceous earth	38.64	93.03	107.91
Foliar spray of 2.5 % Potassium silicate at 60, 90 and 120 DAP	36.60	83.97	97.64
SEm ±	-	1.68	2.30
CD (P=0.05)	NS	5.04	6.89

Table 2.13. Descriptive analysis of chemical properties of soil samples collected from IISR Research Farm

Particulars	pH (1:2.5)	EC (dS/m)	SOC (%)	N kg/ha	P kg/ha	K kg/ha	S kg/ha	Zn kg/ha	Cu mg/kg	Fe mg/kg	Mn mg/kg	Si mg/kg
0-15 cm depth												
Minimum	7.20	0.05	0.27	219.4	5.69	121.3	8.23	0.40	0.96	3.92	5.12	3.87
Maximum	8.40	0.23	0.76	275.5	51.5	369.2	16.0	2.80	3.32	49.3	29.0	46.0
Mean	7.80	0.12	0.56	254.0	20.7	202.9	11.1	0.89	2.29	17.2	12.9	10.3
SD	0.30	0.03	0.09	13.2	6.75	50.3	2.08	0.36	0.55	7.80	4.34	7.83
CV (%)	3.79	26.6	15.2	5.19	32.5	24.8	18.8	41.0	24.0	45.4	33.5	76.4
15-30 cm depth												
Minimum	7.10	0.05	0.18	147.3	5.69	80.4	6.00	0.08	0.84	3.60	4.80	2.53
Maximum	8.60	0.26	0.39	238.2	28.5	227.8	10.1	3.60	2.68	48.2	18.4	22.0
Mean	7.89	0.11	0.27	187.7	14.9	150.0	7.90	0.48	1.74	11.4	10.5	8.02
SD	0.39	0.03	0.05	15.4	4.46	33.8	0.88	0.42	0.42	5.43	3.01	3.38
CV (%)	4.89	32.98	17.51	8.21	30.0	22.5	11.2	86.2	24.4	47.5	28.8	42.2

to 8.40 and 7.10 to 8.60 across the sugarcane research farm with mean value of 7.80 and 7.89 at 0-15 cm and 15-30 cm depth, respectively. The EC values ranged from 0.05 to 0.23dS/m and 0.05 to 0.26 dS/m with mean values of 0.12 and 0.11 dS/m at 0-15 and 15-30 cm depth, respectively. The data clearly stated that soil organic carbon, and macro and micronutrient status decreased with increasing soil depth in most of the cases. Soil organic carbon existed in the ranges of 0.27 to 0.76 and 0.18 to 0.39% with mean values of 0.56 and 0.27% at the depth of 0-15 cm and 15-30 cm, respectively. About 11.8% soil samples showed low categories of soil organic carbon (<0.5%) whereas rest of samples were in medium categories of SOC, except one plot. Contrary to that, 100% soil samples exhibited very low to low categories of available nitrogen (<280 kg/ha) and varied from 219.4 to 275.5 and 147.3 to 238.2 kg/ha at 0-15 and 15-30 cm depth, respectively. However, available P, K and S were found in medium categories based on mean values. Zinc content was found in medium category as per mean value, but 14.4% soil samples exhibited low level of Zn (<0.60 mg/ kg) whereas Cu, Fe and Mn content was found in high level across the farm lands. The plant available silicon was analysed through ammonium acetate method. The plant available silicon ranged from 3.87 to 46.0 mg/kg with a mean value of 10.3 mg/ kg in 0-15 cm depth of soil whereas it varied from 2.53 to 22.0 mg/kg having mean value of 8.02 mg/kg in 15-30 cm depth of soil. The data indicated that 96% soil samples of the farm existed in low category (<20 mg/kg).

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 have 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 have 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 their integration in sugarcane productivity and soil health.

Keeping in view the above facts, an Institute project proposal with consultation of VSI, Pune was executed on following objectives:

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

Field experiment was conducted with the 12 different treatment combinations (Table 2.14) *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. In nutshell, Treatment T-7 (100% N.P.K.+Use of biostimulator derivative @ 2.5 ml/l of water + sett treatment with *Gluconacetobacter diazotrophicus* + sett treatment with *Bacillus subtalis* and *Bacillus cerelus* and foliar application of GA_3 @ 35 ppm at 90, 120 and 150 DAP) have been found the best treatment for cane yield (89.43 t/ha) and significantly influenced over other treatment combinations followed by T-11 (80.16 t/ha) and T-9 (79.60 t/ha.).The no. of tillers, NMC 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-0.13ds/m, N-219 kg/ha,

Table 2.14. Details of treatment evaluated in plant and ratoon cane

T1: 100% N:P:K (Control)
T2: 75% N:P:K (Control)
T3: T1 + Use of bio stimulator derivative @ 2.5 ml/l of water*
T4: T3+ sett treatment (*Gluconacetobacter diazotrophicus*)
T5: T4 + sett treatment (*Bacillus subtilis*)
T6: T5 + sett treatment (*Bacillus cerelus*)
T7: T6 + Foliar application of GA_3 @ 35 ppm at 90, 120 and 150 DAP
T8: T2- Use of bio stimulator derivative @ 2.5 ml/l of water*
T9: T8 + sett treatment (*Gluconacetobacter diazotrophicus*)
T10: T9 + sett treatment (*Bacillus subtilis*)
T11: T10 + sett treatment (*Bacillus cerelus*)
T12: T11 + Foliar 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 bio stimulator will be carried out at 45, 75, 105 DAP. The experiment was conducted in RBD desg with three replications.The Biostimulator were supplied by VSI, Pune.

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-$8.8*10^6$, Actinomyces-$3.74*10^4$, Fungi-$9.31*10^4$.

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

Morning glories (*Ipomoea* spp) are summer annual dicots, and are troublesome weeds in sugarcane cultivated in the northern India. If not controlled, they may compete with sugarcane, interfere in the harvest operation, and reduce yields. They emerge late and develop during the large growth phase of sugarcane fields. Despite the lack of data on the impact of morning glories (especially *Ipomoea* sp.) on the sugarcane growth and yield, their control is important and a concern. With the objectives to study the interfering impact and their effective control, the following field experiments *viz.* (1) Interference of *Ipomoea* sp. on sugarcane productivity; (2) Evaluation of competitiveness ability of sugarcane varieties against *Ipomoea* sp.; and (3) Herbicidal control of *Ipomoea* sp. was conducted during 2020.

Interference of *Ipomoea* sp on sugarcane productivity

A field study on effect of *Ipomoea* sp. with its variable density (0, 0.5, 1.0, 2.0, 3.0, 4.0, 6.0, 8.0, 10., and 15.0/m^2) was conducted in RBD with three replications. Findings revealed that increasing density of *Ipomoea* sp. significantly influenced the NMC, cane length and weight, cane yield (Table 2.17). A density of 15 *Ipomoea*/m^2 being at par with densities of 10 *Ipomoea*/m^2 caused the highest reduction in NMC, cane length and weight cane yield. Similarly, 1-2 *Ipomoea* density/m^2 being at par with even a density of 0.5/m^2 caused significant reduction in NMC, single cane parameters and yield of sugarcane. Considering economic loss, a density of 1-2 *Ipomoea* sp./m^2 may be considered as an economic threshold level of *Ipomoea* infestation, beyond which an effective weed control measure is essential. Increasing density of *Ipomoea* sp. also influenced its fresh and dry matter production as well as fruit and seed yield (Table 2.16). *Ipomoea* infestation with density beyond 2/m^2 produced significantly higher dry weight and fruit and seed production. The highest fresh and dry biomass as well as seed yield of *Ipomoea* sp. recorded under its infestation level of 10-15/m^2 indicates the huge increase in soil weed seed bank which may create severe problem of *Ipomoea* sp. in succeeding years, if not controlled effectively.

Screening of herbicides for the control of *Ipomoea* sp. in sugarcane

Weeds grow along with sugarcane crop and limit the cane and sugar yield according to the species and intensity. Shift in weed flora has been recorded by following the same practice of weed control for long period. Further, the nature has encouraged the twining weeds, which are germinated late and growing by climbing on the sugarcane stalk after last interculture and earthing up operations. These weeds are posing problems like blocking the sunlight to the top plane by spreading their branches on the top plane. It also gives trouble to the harvesting labour and increasing cost of

Table 2.15. Effect of different density of *Ipomoea* sp on the growth and yield of sugarcane

Density/m^2	NMC (000/ha)	% Decrease	Cane length (m)	% Decrease	Cane weight (kg)	% Decrease	Cane yield (t/ha)	% Decrease	*Ipomoea* sp plant dry weight (kg/ha)	*Ipomoea* seed weight (kg/ha)
0.0	158.3	0.0	2.3	0.0	0.99	0.0	111.8	0.0	0.0	0.0
0.5	144.3	8.8	2.2	4.9	0.99	0.0	108.2	3.2	202.2	69.7
1.0	140.5	11.2	2.1	6.3	0.96	3.0	101.9	8.9	252.8	78.8
2.0	137.8	12.9	2.1	8.0	0.89	10.7	97.2	13.0	338.9	84.9
3.0	133.5	15.6	2.0	9.6	0.86	13.4	96.0	14.1	405.6	100.6
4.0	132.2	16.4	2.0	10.2	0.79	20.1	90.9	18.7	411.1	103.7
6.0	128.9	18.5	2.0	10.8	0.79	20.8	88.2	21.1	475.0	112.5
8.0	121.0	23.5	2.0	12.4	0.79	20.5	83.0	25.8	577.8	127.7
10.0	116.4	26.4	1.9	15.8	0.75	24.8	77.9	30.3	686.1	146.3
15.0	112.3	29.0	1.8	19.0	0.73	26.5	75.1	32.8	744.4	170.2
LSD (p=0.05)	8.9	-	0.2	-	0.1	-	9.2	-	168.1	29.8

Table 2.16. Competitive behaviour of sugarcane varieties against *Ipomoea* sp.

Variety	% reduction due to *Ipomoea* infestation					
	Tillers	NMC	Cane yield	Cane length	Cane girth	Cane weight
CoJ 64	17.0	55.5	31.2	55.5	55.5	2.3
Co 0238	23.4	49.2	39.7	49.2	49.2	4.3
CoS 08279	11.9	38.4	38.5	38.4	38.4	19.2
Co 12027	13.9	16.8	5.8	16.8	16.8	15.8
CoLk 11206	14.8	5.5	10.4	5.5	5.5	12.8
CoLk 12203	6.7	8.0	25.9	8.0	8.0	6.0
CoLk 14201	9.9	39.0	24.6	39.0	39.0	13.0
CoPb 14181	4.4	8.3	15.0	8.3	8.3	2.6
CoPb 14182	19.0	11.0	28.4	11.0	11.0	1.0
CoPant 14222	16.2	4.3	12.0	4.3	4.3	1.0

production. Hence, these weeds are to be controlled effectively by suitable control measures. With this objective, a field experiment comprising of application of post-emergence herbicides was laid out in RBD with three replications. Results revealed that post-emergence application of almost all the herbicides undertaken in study applied at 30- and 50-days stage growth of *Ipomoea* sp were found to be the most effective against this binding weed and controlled 100% (Table 2.19). Among different herbicides, application of Flumioxazin 150 g/ha alone or in combination with 2,4-D 1500 g/ha as well as Ametryn+2,4-D @ 1500+1500 g/ha or Metribuzin+2,4-D @ 1250+1500 g/ha were quite effective and controlled 70-80% other weeds *viz. Echinochloa colona* and *Dactyloctenium aegyptium*, in addition to 100% control of *Ipomoea* sp. However, application of metribuzin 1250 g/ha and Saflufenacil 70 g/ha failed to manage other grassy weeds infested the sugarcane field.

Evaluation of sugarcane varieties for drought tolerance

The experiment was laid out with an objective of 'Identification of drought tolerant varieties suitable for specific agro-climatic condition' on 8th March 2019 in strip plot design with early maturing CoLk 94184, CoPK 05191 & CoLk 9709; mid-late maturing: CoLk 09204, CoLk 11206 & CoS 08279; and two Irrigation regimes *viz.* IW/CPE ratio 1.0 & IW/CPE ratio 0.3 with three replications. Sugarcane crop was irrigated 10 times in treatment IW/CPE ratio 1.0 (IS 1.0), and four 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 1267.7 mm rainfall was received during the crop duration in 48 rainy days. Rainfall distributed from June to September. In winter, rainfall occurs in December 2019 and January 2020. At 50 days after planting, number of tillers, weight of roots and total dry weight was numerically non significant.

Table 2.17. Performance of irrigation scheduling and varieties on tillers, NMC, cane yield and CCS

Treatment	Tillers '000/ha (90 DAP)	NMC ('000/ha)	% extraction juice	Cane yield (t/ha)	CCS (t/ha)
A. Irrigation Schedule					
IS 1.0	131.9	95.72	62.05	75.48	9.60
IS 0.3	124.1	86.26	60.64	63.92	7.88
CD 5%	6.55	9.44	1.48	6.51	0.61
B. Varieties					
CoLk 94184	127.9	90.78	61.33	70.20	8.27
CoPk 05191	135.3	100.23	62.21	79.04	9.81
CoLk 9709	125.0	85.01	61.05	62.74	8.60
CoLk 9204	124.2	86.36	60.91	65.33	8.05
CoLk 11206	131.3	96.48	61.79	75.60	9.61
CoS 08279	124.5	87.06	61.22	66.37	8.10
CD 5%	NS	8.61	0.70	7.29	1.09

Results (Table 2.17) revealed that among the six varieties of sugarcane, CoPK 05191 produced the highest number of tillers (90 DAP), NMC, sugarcane yield, juice extraction percentage and CCS t/ha, which may be due to production of higher root dry weight, LAI and average cane weight. Minimum reduction in sugarcane yield with tune of 11.89 per cent with treatment IS 0.30 over treatment IS 1.0 with variety CoPk 05191 followed by variety CoLk 11206 which was at par with CoLk 94184 (16.8%).

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

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

The field trial to assess the potassic organo-mineral fertilizer (OMF) in sugarcane was conducted during spring- The OMF contains 10% K using feldspar and it has been developed by ICAR-CAZRI, Jodhpur. Keeping in view, its releasing pattern, sugarcane certainly be benefitted for its K utilization over the crop growth period. The experiment comprising of ten treatments in different combinations of MOP, OMF and FYM with 50 and 75% recommended levels of potash was designed in randomized block design with three replications. The trial was laid out on 23rd February 2020, planted sugarcane crop (cv. CoLk 09204). The experiment is progressing well and observations were recorded as per protocol of the experiment.

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

The experiment with approved research programme and layout plan has been planted in the autumn season 2020. The crop of sugarcane (first cycle) is in progress at the Institute field and its growth is satisfactory. Necessary observations are being recorded.

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

Sugarcane is a long duration crop and requires 150-180 kg N, 60 kg P_2O_5 and 60 kg K_2O nutrients in sub-tropical India. Nitrogen plays a crucial role in tillering, foliage formation, stalk formation; shoot and root growth. Micronutrients like zinc and copper are essential for activity of various enzymes. Zn is also important for bio-synthesis of plant growth regulator. Copper is important in carbohydrate and protein metabolism. It is also required for lignin synthesis process. Biofertilizers work as supplement to chemical fertilizers and provide sustainable sugarcane growth and yield. Nutrient management based on nanofertilizer and biofertilizer may enhance nutrient use efficiency, sugarcane yield and sustain soil health.

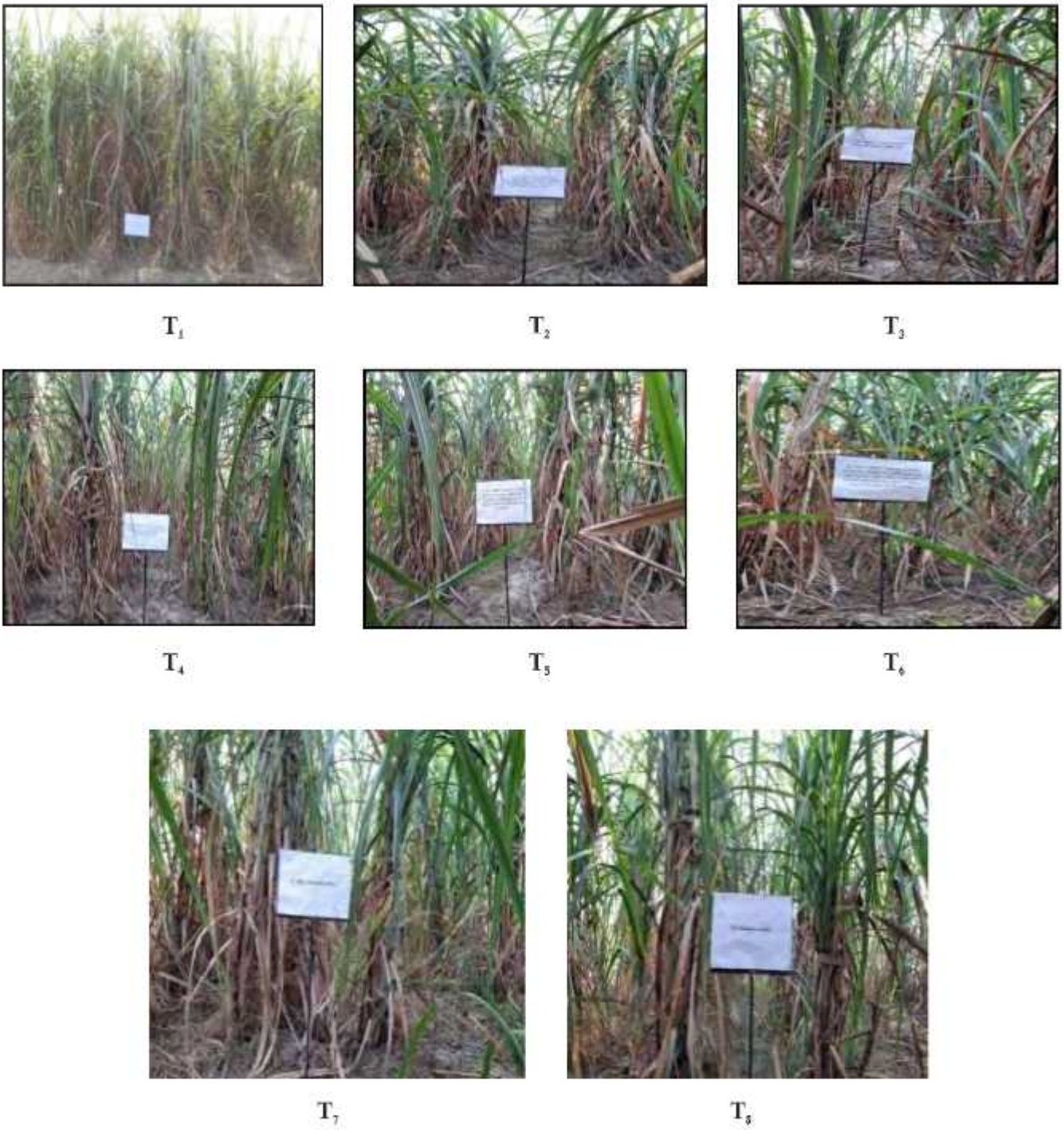
The experiment was laid out in randomized block design with eight treatments of nutrient management based on nanofertilizer and biofertilizer *viz.* T_1: Nano N @ 1250 ml/ha in two spray+100% PK, T_2: Nano N @ 1250 ml/ha in two spray+100% PK+ Nano Zn @ 1250 ml/ha in two spray + Nano Cu @ 1250 ml/ha in two spray, T_3: 50 % RDN+ Nano N @ 1250 ml/ha in two spray+ 100% PK, T_4: 50% RDN+ Nitrogen fixing bacteria+ Nano N @ 1250 ml/ha in two spray+ 100% PK, T_5: 50% RDN+ Nano N @ 1250 ml/ha in two spray+ 100% PK+ Nano Zn @ 1250 ml/ha in two spray+ Nano Cu @ 1250 ml/ha in two spray, T_6: 50% RDN+ Nitrogen fixing bacteria+ Nano N @ 1250 ml/ha in two spray+ 100% PK+ Nano Zn @ 1250 ml/ha in two spray+ Nano Cu @ 1250 ml/ha in two spray, T_7:RDF 150-60-60 (NPK), and T_8: Absolute control and replicated three times. Planting of sugarcane plant crop was done on February 29, 2020. Uniform application of SSP and MOP was done @ PK: 60-60 and nitrogen dose varied according to treatment. Urea was applied as per treatment at different stages *viz.*, basal, first top dressing at 90 DAP and second at 120 DAP. Seed canes were treated as per treatment with *Gluconacetobactor diazotropiclius* N fixing bacteria. Nano N, Nano Cu, and Nano Zn was sprayed on three to four leaf stage.

Data related to germination %, tillering pattern, dry matter accumulation was recorded at different growth stages. It was observed that 50% RDN+ Nitrogen fixing bacteria+ Nano N @ 1250 ml/ha in two spray+ 100% PK treatment (T6) has better growth as compared to other treatments. Sugarcane crop under different nutrient management treatments have been shown in Fig. 2.3.

Nanofertilizer and biofertilizer based sustainable nutrient management practice for sugarcane plant crop obtained after getting cane yield data. Further, various quality parameters will be analyzed in laboratory. Ratoon initiated in February 2021 for getting results of nanofertilizer and biofertilizer based nutrient management on ratoon crop.

ICAR funded Agri.-Consortia Research Programme on Water

Eight sugarcane varieties from early maturing group and eight from mid-late maturing group were irrigated with four irrigation treatments. The plots were irrigated at 60% depletion of available soil moisture with the following quantity of irrigation water:



T_1 T_2 T_3

T_4 T_5 T_6

T_7 T_8

Fig. 2.3. Sugarcane crop under different nutrient management treatments (Details of T_1 to T_8 are given in text)

I_1=60% of crop water requirement

I_3=80% of crop water requirement

I_3=100% of crop water requirement

I_4=120% of crop water requirement

Data on quantity of irrigation water applied, germination percentage, tiller count and leaf area index (LAI) at onset of monsoon were recorded. In early maturing varieties, the highest LAI (4.4) was observed with I1 irrigation treatment and the lowest (3.7) with I4 irrigation treatment whereas in mid-late maturing varieties, irrigation treatment I4 resulted in the highest LAI (6.07) and irrigation treatment I2 resulted in the lowest leaf area index (5.44). In early maturing varieties, the highest LAI (4.88) was observed in CoPK 05191 followed by Co 0238 (4.71). The lowest leaf area index (3.38) was observed in CoS 08272. In mid-late maturing varieties, the highest LAI. (7.13) was in CoPK 05191 followed by CoSe 11453 (6.42). The lowest LAI (4.56) was in CoS 97261.

In early maturing varieties, the highest number of millable canes (155.66 thousand) were recorded in CoLk 94184 followed by UP 05125 (141.38 thousand), whereas the lowest number of millable canes (86.37 thousand) were recorded in Co 0118 (Fig 2.4). Sugarcane yield was the highest (151.63 t/ha) for CoPK 05191 followed by UP 05125 (130 t/ha), the lowest sugarcane yield (84.94 t/ha) was recorded in Co 0118. Irrigation water use efficiency (IWUE) was the highest (1670 kg/ha-cm) for CoPK 05191 followed by UP 05125 (1431 kg/ha-cm), the lowest IWUE (936 kg/ha-cm) was recorded in Co 0118. In this variety group, the highest number of millable canes (NMC) were observed in I_3 irrigation treatment (134.4 thousand), followed by I_2 irrigation treatment (132.3 thousand). The lowest NMC (118.4 thousand) were observed with I_1 irrigation treatment (Fig. 2.5). The highest IWUE (1444 kg/ha-cm) was observed in I2 irrigation treatment and the lowest IWUE (1154 kg/ha-cm) was recorded with I3 irrigation treatment. Sugarcane yield was the highest (131.83 t/ha) with I2 irrigation treatment and the lowest (106.39 t/ha) with I3 irrigation treatment.

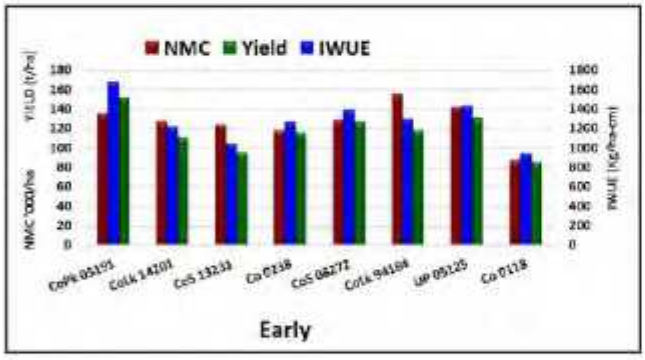


Fig. 2.4. Number of millable canes, IWUE and sugarcane yield of early maturing varieties

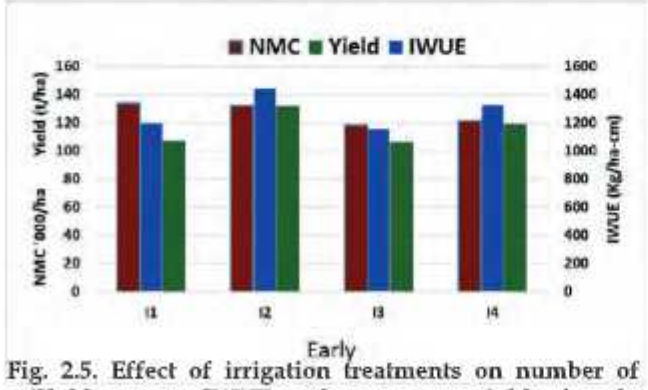


Fig. 2.5. Effect of irrigation treatments on number of millable canes, IWUE and sugarcane yield of early maturing varieties

In mid-late maturing varieties, the highest number of millable canes (135.44 thousand) were recorded in Co 05011 followed by CoLk 09204 (132.76 thousand), whereas the lowest number of millable canes (99.06 thousand) were recorded in CoS 09232 (Fig. 2.6). Sugarcane yield was the highest (133.27 t/ha) for CoLk 09204 followed by CoLk 14203 (131.95 t/ha). The lowest sugarcane yield (92.47 t/ha) was recorded in CoS 97261. Irrigation water use efficiency (IWUE) was the highest (1469 kg/ha-cm) for CoLk 09204 followed by CoLk 14203 (1452 kg/ha-cm), the lowest IWUE (1018 kg/ha-cm) was recorded in CoS 97261. In this variety group, the highest number of millable canes (NMC) were observed in I4 irrigation treatment (129.7 thousand), followed by I2 irrigation treatment (117.4 thousand). The lowest NMC (114.4 thousand) were observed with I1 irrigation treatment (Fig. 2.6). The highest IWUE (1363 kg/ha-cm) was observed in I4 irrigation treatment and the lowest IWUE (1049 kg/ha-cm) was recorded with I3 irrigation treatment. Sugarcane yield was the highest (122.69 t/ha) with I4 irrigation treatment and the lowest (114.56 t/ha) with I3 irrigation treatment (Fig. 2.7).

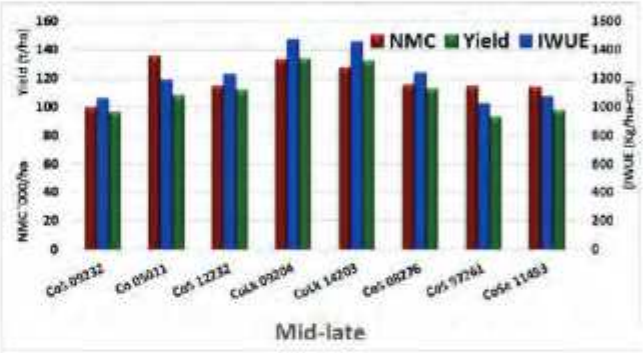


Fig. 2.6. Number of millable canes, IWUE and sugarcane yield of mid-late maturing varieties

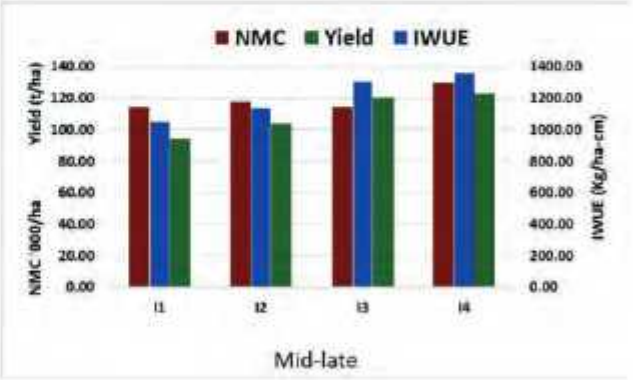


Fig.2.7. Effect of irrigation treatments on number of millable canes, IWUE and sugarcane yield of mid-late maturing varieties

The results indicate that in early maturing variety group, CoPK 05191 is the highest yielder and most efficient water user. In this group, the poor yielder variety is Co 0118. This variety is also most inefficient water user. The early maturing varieties performed best in I2 irrigation treatment. In mid-late maturing variety group, CoLk 09204 and CoLk 14203 are the highest yielder and the most efficient water user varieties. In this group, the most poor yielder variety is CoS 97261. This variety is also most inefficient water user. The mid-late maturing varieties performed best in I3 and I4 irrigation treatments.

Sustaining sugarcane yield under multiple ratooning through drip irrigation

The experiment was initiated from 4th ratoon. This year, 7th ratoon crop was initiated in the first week of February after stubble shaving and interculturing. The crop was drip irrigated daily and fertigation was done weekly. Recommended dose of fertilizer *i.e.* 200 kg N, 60 kg P_2O_5 and 60 kg K was applied through fertigation in 20 equal doses. Irrigation water was kept equal to pan evaporation. Drip irrigation treatments were provided with irrigation water equal to 0.6 times the pan evaporation, 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 irrigation water use efficiency (871.2 kg/ha-cm) was recorded in drip irrigated ring-pit planting system (Table 2.18). The lowest irrigation water use efficiency (276.6 kg/ha-cm) was recorded in surface irrigated crop planted at 90 cm spacing. The highest sugarcane yield (66.39 t/ha) was recorded in drip irrigated ring-pit planting system (Table 2.19). The lowest sugarcane yield (32.57 t/ha) was recorded in surface irrigated crop planted at 90 cm spacing.

Table 2.18. Effect of irrigation treatments on irrigation water use efficiency (kg/ha-cm)

Irrigation/Planting treatment	Plant	Average for first to sixth ratoon	Seventh ratoon
T2: Planting at 75 cm row to row and at alternate row drip irrigation-fertigation	1106.7	1552.7	758.5
T3: Paired row planting at 40 x 110 x 40 cm with drip irrigation - fertigation	1214.6	1455.8	816.4
T4: Paired row planting at 45 x 135 x 45 cm with drip irrigation - fertigation	1066.6	1341.3	820.6
T5: Paired row planting at 60 x 120 x 60 cm with drip irrigation - fertigation	1226.1	1477.1	850.1
T6: Paired row planting at 40 x 110 x 40 cm with sub-surface drip irrigation-fertigation	1197.7	1438.8	824.3
T7: Surface drip in Ring- pit planting method (105 x 75 cm) with drip irrigation-fertigation	1321.2	1788.9	871.2
Average for drip irrigation	1188.8	1509.1	823.5
T1: Planting at 75 cm row to row distance with surface irrigation & recommended fertilizers application in soil	583.0	656.8	334.8
T8: Planting at 90 cm row to row distance with surface irrigation & recommended fertilizers application in soil	599.0	633.4	276.6
Average for surface irrigation	591.0	645.1	305.7
SE±	17.8		18.6
CD (p= 0.05)	31.4		32.7

Table 2.19. Effect of irrigation treatments on sugarcane yield (t/ha)

Irrigation/Planting treatment	Plant	Average for first to sixth ratoon	Seventh ratoon
A. Only Irigation treatment			
T2: Planting at 75 cm row to row and at alternate row drip irrigation - fertigation	74.37	78.20	62.99
T3: Paired row planting at 40 x 110 x 40 cm with drip irrigation-fertigation	81.62	75.86	61.68
T4: Paired row planting at 45 x 135 x 45 cm with drip irrigation-fertigation	71.68	70.24	62.38
T5: Paired row planting at 60 x 120 x 60 cm with drip irrigation-fertigation	82.40	77.03	61.06
T6: Paired row planting at 40x 110 x 40 cm with sub-surface drip irrigation-fertigation	80.48	75.00	61.79
T7: Surface drip in ring-pit planting method (105 x 75 cm) with drip irrigation-fertigation	88.78	90.25	66.39
Average for drip	79.89	77.76	62.72
B. Surfacing treatment			
T1: Planting at 75 cm row to row distance with surface irrigation & recommended fertilizers application in soil	65.29	55.32	35.25
T8: Planting at 90 cm row to row distance with surface irrigation & recommended fertilizers application in soil	67.09	54.47	32.57
Average for surface	66.19	54.90	33.91
SE±	1.44		1.40
CD, 0.05	2.53		2.46

CHAPTER 3

Management of Insect Pests and Diseases

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

Roving survey of insect pests and diseases of sugarcane was carried out in Lahsuriya Purva, Andapur, Parsehra, Barkherva, Bhadurpur, Behta villages in Lakhimpur Kheri District and Mausalia, Kauraha, Sumerpur, Haldermau Parsouni Purva, Virpur Katra villages in the command areas of Balramur Chini Mill, Maizapur (Gonda). High incidence of red rot was noticed in variety Co 0238 in all the surveyed areas. The incidences of red rot in affected fields under command areas of Balrampur Chini Mill, Gonda ranged between 30 and 50% in variety Co 0238. In Lakhimpur –Kheri area also, the incidences of red rot in affected fields ranged between 30 and 60%. Besides red rot, sporadic incidence of Yellow leaf (5-10%) and smut were also observed in Co 0238. Sporadic incidences of stalk borer and top borer were observed in certain locations.

Survey of insect pests and diseases of sugarcane was carried out in Ayodhya and Basti zone of K.M. Sugar Mills Ltd. (Table 3.1).

Table 3.1. Area surveyed in Ayodhya and Basti zone in the command area of K.M. Sugar Mills Ltd.

S.N.	Name of the Farmers	Villages
Ayodhya Zone		
1	Sri Shesh Dutt Pandey	Ibrahimpur, Duali, Ayodhya (U.P)
2	Sri Hari Lal	Ibrahimpur, Duali, Ayodhya (U.P)
3	Sri Keshav Ram	Purva Kashinath, Ayodhya (U.P)
4	Sri Surya Bhan Singh	Salarpur, Ayodhya (U.P.)
5	Sri Rajeet Ram	Haripur Jalalabad, Ayodhya (U.P)
6	Sri Rakesh Kumar	Haripur Jalalabad, Ayodhya (U.P)
Basti zone		
1	Sri Sunil Ojha	Baihar, Basti (U.P)
2	Sri Sukhdev	Singhauria , Basti (U.P)
3	Sri Ram Krishna	Paraspura, Basti (U.P)
4	Sri Shri Ram	Khirihwa, Basti (U.P)
5	Sri Thakurdin	Bawanpur , Basti (U.P)

Co 0238 is dominating sugarcane variety that covers a sizeable area in both Ayodhya and Basti zones. Incidence of red rot was moderate to severe in Co 0238. Low to moderate incidence of top borer, stalk borer and white fly were noticed in Co 0238.

Sugarcane fields in command areas of Biswan Sugar Mill, Sitapur were surveyed for the incidence of insect pest and diseases. In general, sugarcane varieties grown in the area are CoPk 05191 and CoLk 94184 *etc.* It has been observed that sugarcane varieties other than Co 0238 were healthy. The incidence of red rot were observed in Co 0238 in most of the areas ranged from 10 to 75%. Sporadic incidences of smut, GSD, YLD, Leaf Scald were also observed. Incidence of Pokkah boeng was observed in most of the locations surveyed. Low incidence of top borer and internode borer were noticed.

It was informed by Hasanpur Sugar Mill (Bihar) that the maize is attacked by fall army worm as maize is the main crop of area. On close observations, it has been found that maize was attacked by army worms not by fall army worm. Larvae collected from infested maize fields and brought to the laboratory were identified as army worms.

Exhaustive survey for red rot and other sugarcane disease and insect pests was carried out in different villages of Lakhimpur-Kheri district and the command areas of Balrampur Sugar Mill, Gonda. The incidence of red rot in affected fields under command areas of Balrampur Sugar Mill and Lakhimpur-Kheri, ranged from 30-50 and 30-60% respectively on var. Co 0238 (Fig. 3.1, 3.2.). Sporadic incidences of Yellow leaf disease (5%-10%) and smut, as well as stalk borer and top borer were also observed in certain locations.

Fig. 3.1. High incidence of red rot

Fig. 3.2. Co 0238 showing red rot symptoms

Enhancing efficacy of *Trichoderma* based red rot management system

Three most promising isolates (STr-64, STr-83 and STr-126) were evaluated in field for their growth promoting potential in sugarcane. The field experiment was laid out in randomized block design with 13 treatments on *var* Co 0238: T_1 to T_3: application of the selected *Trichoderma* isolates as sett treatment and soil application through *Trichoderma* colonized FYM at time of planting; T_4 to T_6: application of *Trichoderma* isolates as sett treatment and soil application through FYM + 50% RDF (recommended dose of fertilizers 150:60:60); T_7 to T_9: application of selected *Trichoderma* isolates as sett treatment and soil application through FYM + 100% RDF; T_{10}: FYM +100% RDF; T_{11}: FYM +50% RDF; T_{12}: FYM alone and T_{13}: Control (no FYM or inorganic fertilizers). The results revealed that the germination ranged between 29 (control) and 37.5% (STr-64 + 100% RDF) in the different treatments. Application of the three *Trichoderma* isolates alone or in combination with different fertilizer doses resulted in an increase in germination by 7.0 to 17.6% over FYM application alone (T12). There was no significant effect of various treatments on sugarcane girth, brix and Pol %. However, there was significant variation in cane length, yield and NMC among the different treatments. Overall, the effect of *Trichoderma* on sugarcane yield was more pronounced under low nutrition conditions. The application of *Trichoderma* isolates STr-83 and STr-126 without inorganic fertilizer application resulted in 24.5 and 22.1% increase in yield over control, respectively. Similarly application of these two isolates along with 50% RDF also showed a 17-18% increase in yield over 50% RDF application alone. However, *Trichoderma* application along with 100% RDF did not result in further yield increase compared to 100% RDF alone. Based on the results, two promising *Trichoderma* isolates *viz.* STr-83 (*T. longibrachiatum*) & STr-126 (*T. harzianum*) were identified with the potential to enhance sugarcane yield by 17-24.5% especially under conditions of low inorganic fertilizer usage.

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

Isolation, identification and pathogenicity of wilt pathogen in sugarcane

The survey and isolation were done to collect the wilt diseased sugarcane samples from different varieties from field of ICAR-IISR, Lucknow campus and Faizabad (Fig. 3.3 and 3.4). The pathogen was isolated and characterized morphologically (Fig. 3.5). The cultures were whitish, pinkish and purple in appearance. Micro (cylindrical and smaller in size) and macro conidia (sickle shaped) were observed. On the basis of these characters, pathogen has been identified as *Fusarium* spp.

Fig.3.3 Wilt infected plants

Fig.3.4 Wilt infected split cane

Fig. 3.5 Survey, sampling and isolation of wilt pathogen

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

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

In high SOC, soils microarthropods were more in number than low SOC soils (Fig.3.6). However, effect of nutrient sources (inorganic & organic) on faunal build-up was more in low SOC plots in comparison to high SOC plots (Fig. 3.6). Soil pH and EC ranged between 7.8 and 8.0 and 0.0.06 and 0.13 dSm^{-1}. The SOC ranged between 0.52 and 1.95 percent. Av N was low in low organic carbon soils (Table 3.2).

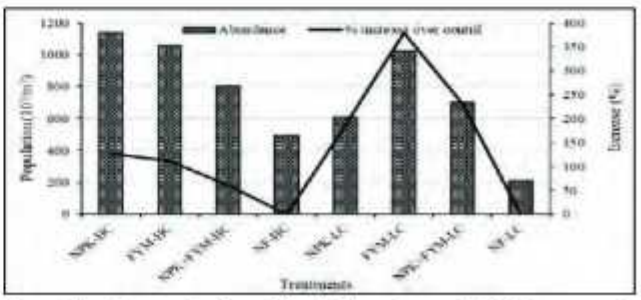


Fig. 3.6 **Impact of nutrient inputs and SOC on soil microarthropod abundance in sugarcane land use systems** (HC= High SOC; LC = Low SOC; NPK= Recommended doses of inorganic fertilizer; FYM=Recommended doses of farmyard manure; NF= No fertilizer application)

Table 3.2. Mean value of soil properties and abundance of soil microarthropods

	pH	EC	OC	Av N	Av P	Av K
NPK-HC	7.90	0.13	1.80	360.60	78.17	265.32
FYM-HC	7.80	0.12	1.95	370.00	78.17	273.36
NPK+FYM-HC	7.80	0.11	0.90	266.50	64.38	263.44
NF-HC	7.90	0.10	0.81	272.80	55.95	244.95
NPK -LC	7.90	0.08	0.61	250.80	68.98	540.02
FYM-LC	7.90	0.06	0.52	232.00	52.11	268.26
NPK+FYM-LC	7.80	0.10	0.67	279.10	70.51	263.98
NF-LC	8.00	0.06	0.53	232.00	42.15	385.65

(HC= High SOC; LC = Low SOC; NPK= Recommended doses of inorganic fertilizer; FYM=Recommended doses of farmyard manure; NF= No fertilizer application)

Impact of different pest management tools on non-target soil arthropods

A total of 418 number of specimens were collected from various treatments. Out of these, 201 were collembolans and 151 were mites, three specimens were proturans and rest were other insect juveniles or adults. Based on Shannon Index, T_1, T_5, T_9 & T_{10} supported diverse fauna, while, T_3 & T_8 had the least diverse fauna (Table 3.3). As far as abundance is concerned, T_1 had the highest number of fauna (79) per core followed by T_5 (61) and T_6 (51). The lowest population per core was recorded in T_8 (8) and T_2 (21) (Fig. 3.7). Lower abundance and diversity of microarthropod fauna in *P. lilacinum* application could be due to the fact that *P. lilacinum*, being pathogenic to nematodes and insects, probably disturbed the soil food chain as Collembolan and mites feed on nematodes and fungi. Amongst the chemical management tools, Chlorantraniliprole (T_5) and Imidacloprid (T_6) had the least effect on diversity and abundance of studied fauna. Pesticides are usually toxic to organisms but safer pesticides having species specific reaction may not alter community composition of arthropods and if judiciously used may have short term effect on non-targeted organisms.

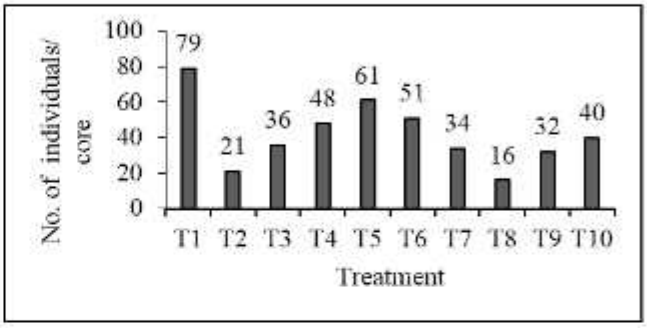


Fig. 3.7 Abundance of soil micro-arthropods in different treatments

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

Extraction of sex pheromones in organic solvents

Table 3.3. Diversity of micro-arthropod fauna in different treatments

Treatment	Taxa (No.)	Dominance (Simpson index)	Shannon Diversity
T_1: *Beauveria bassiana* @ 2.5 kg/ ha ($1x10^8$ cfu/g)	23	0.09	2.79
T_2: *Metarhizium anisopliae* @ 2.5 kg/ha ($1x10^8$ cfu/g)	10	0.12	2.20
T_3: *Purpureocillium lilacinum* @ 2.5 kg/ha ($1x10^8$ cfu/g)	9	0.29	1.70
T_4:*Bacillus subtilis* @ 3 litre /ha ($1x10^9$ cfu/ml)	13	0.14	2.20
T_5: Chlorantraniliprole 18.5% SC @ 600 ml/ ha	17	0.08	2.67
T_6: Imidacloprid 17.8% SC @ 350 ml/ha	13	0.14	2.20
T_7: Bifenthrin 10% EC @ 1.0 litre/ ha	12	0.14	2.15
T_8: Chlorpyrifos 20% EC @ 6.25 litre/ha	8	0.14	2.01
T_9: Weekly irrigation for 4 weeks from planting onwards	17	0.09	2.65
T_{10}: Untreated Control	16	0.13	2.36

Cane shoots infested by top borer were cut at the stage of closed exit hole that indicates now pupae have been formed and brought to the laboratory. Infested top shoots were splitted and pupae were collected in wide mouth glass tubes. On the basis of sexing, male and female pupae were kept at ambient temperature in separate glass tubes to avoid mating. On emergence of moths, one hundred (100) virgin female moths were released into the THF Cutter whose inlet was covered with tissue paper and outlet was connected to sintered gas dissolving bottle. Inlet of sintered bottle was immersed in solvent (150 ml Methanol AR Grade) and outlet was above the solvent surface means in the air. Outlet of sintered bottle was connected with electric vacuum pump. For connecting all units with each other, 9.0 mm silicone pipe was used. The electric pump was on and off for 15 minutes alternatively for 10 times to get maximum gland scent in to solvent. The solvent with scent was stored in reagent glass bottles at 5°C in refrigerator.

Another method for the extraction of sex scent was used as described by Collins and Potts (1932). The abdomen tips from 7th segments were clipped off in to solvent (Methanol AR Grade) and shaked well on rotary shaker for 150 minutes and stored at 5°C in refrigerator.

Testing of extracts against male moths of top borer:

There were ten replications for each of both extracts obtained by two methods, one Whatman's filter paper per replication was taken and dipped in extracts and solvent was evaporated. Such dried filter paper was stuck with glue on the upper inner surface of the plastic jar, (20x20 cm). In each jar, 10 male top borer moths were released at the bottom of jar and close visual observations were made. Just after release of moths, it was observed that no male moths were attracted to treated filter papers in scent Extract A and B. Attraction of male moths was noticed 15 minutes after release and it was maximum at 45 minutes after release (26% in extract A and 27% in extract B). Cumulative per cent attraction of female moths 24 hrs after release was 67 per cent and 71 per cent in extract A and extract B, respectively (Fig. 3.8).

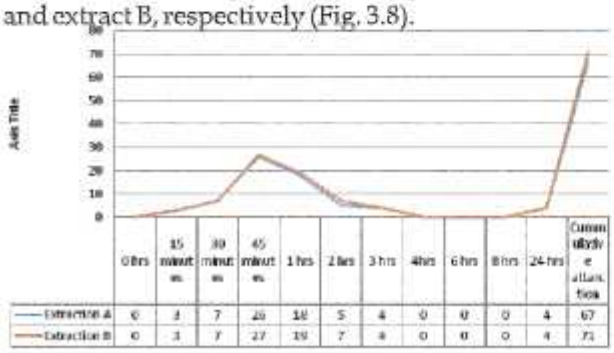


Fig. 3.8 Per cent attraction of male moths of top borer of sugarcane to filter papers treated with female scents

Distribution and relative abundance of different species of termites

Data collected from different fields of the experimental farm at ICAR-IISR, Lucknow (Table 3.4), revealed a heterogenous distribution pattern of the termite species. Also, within a field size of one hectare, more than one species of termite was recorded. Data on relative abundance of different species revealed that *Odototermes obesus* occupied the maximum percentage of occurrence (28.57%) followed by *Microtermes obesi* (21.42%), *O. horni* (14.28%), *O. vaishno* (14.28%), *O. bellahunisensis* (14.28%) and *Odototermes* sp. (7.14%) (Fig. 3.9).

Table 3.4. Distribution of termite species in different fields of IISR Experimental Farm

S. No.	Field No.	Termite species
1	D-29	*Odontotermes* sp.
2	D-41	*O. vaishno*
3	D-44	*O. obesus*
4	E-21	*O. vaishno*
5	E-42	*O. obesus, Microtermes obesi*
6	E-43	*O. belahunisensis*
7	F-23	*O. obesus*
8	F-38	*M. obesi*
9	F-40	*O. horni*
10	F-43	*O. obesus, M. obesi*
11	F-49	*O. horni, O. bellahunisensis*

Fig 3.9. Relative abundance of different termite species in the experimental area

Seasonal abundance of termites

Pooled data of monthly sampling of termites from 11 designated fields from IISR Experimental Farm, Lucknow revealed the highest percent incidence in the month of August (25.45%) followed by July (22.73%), September (21.82%), October (18.18%) and June (15.45%), while the lowest termite incidence was recorded in January (4.55%) followed by February (5.45%) and March (7.27%). It has been observed that monsoon season was favourable for population build-up, while winter season was unfavourable for growth and development of the termites (Fig. 3.10).

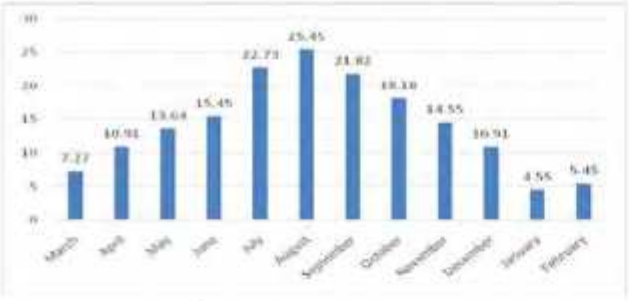


Fig 3.10 Seasonal abundance and per cent incidence of termites in sugarcane

Environmental Impact Quotient (EIQ) and EIQ-Field Use Rating (EIQ-FUR) of different chemical insecticides used against termites

EIQ value was the lowest (18.3) in case of Chlorantraniliprole followed by Chlorpyrifos (26.9), Imidacloprid (36.7) and Bifenthrin (3.8) (Table 3.4). The value of EIQ-FUR was also the lowest in Chlorantraniliprole (1.7) followed by Imidacloprid (2.0), Bifenthrin (3.8) and Chlorpyrifos (28.7).

It is evident from the Table 3.5 that the number of taxa, diversity and abundance of micro-arthropods was the highest in Chlorantraniliprole, while it was the lowest in Chlorpyrifos. Impact of Imidacloprid and Bifenthrin was moderate on number of taxa, diversity and abundance of micro-arthropods. Ecological component of EIQ-FUR for Chlorpyrifos was the highest to the extent of 77.6, while it was the lowest to the tune of 4.0 in case of Chlorantraniliprole. EIQ and EIQ-FUR values indicated that Chlorantraniliprole was the safest insecticide with reference to environmental impact followed by that was Imidacloprid, Bifenthrin and Chlorpyrifos.

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

The preliminary study on taxonomic and functional metagenomic analysis of the whole gut microbiota of the major termite species of sugarcane, *Odontotermes obesus* revealed predominance of bacteria. Bacteroidetes and Proteobacteria were the two most predominant phylum present in the gut. The most abundant bacterial genus were *Treponema* and *Pseudomonas*. While the most prevalent species were *Treponema azotonutricium* and *T. primitia*.

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

(i) Egg parasitoid, *Trichogramma chilonis* Ishii (sugarcane adapted strain)

The study on biological attributes of sugarcane adapted strain of *T. chilonis* (collected from egg masses of top borer in March, 2020) on eggs of *Corcyra cephalonica* in the laboratory at 28 ± 2°C and 60 ± 5% relative humidity suggested varied adult longevity of *T. chilonis* from 2.5 to 3.4 days in F_1 to F_3 generations (Table 3.6). The fecundity rate was high (93.0 ± 4.23) in F_1 generation as compared to F_2 and F_3 generations. The adult emergence (53.8 to 54.54%) with more male and immature mortality was observed in F_1 generation. The female ratio was found more than 50% in F_2 generation. 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* showed less variability in laboratory due to limited selection inbreeding (crossing among siblings) gaining through an adaptation period with larger variations in their biological attributes.

Table 3.5. EIQ and EIQ-FUR for different chemical insecticides used in the experiment

Insecticides applied	% a.i.	Dose	EIQ*	EIQ-FUR*	Field Use EIQ Components		
					Consumer	Worker	Ecological
Chlorantraniliprole	18.5	600 ml/ha	18.3	1.7	0.6	0.7	4.0
Imidacloprid	17.8	350 ml/ha	36.7	2.0	0.6	0.4	4.9
Bifenthrin	10.0	1 lit/ha	44.4	3.8	0.7	1.2	9.5
Chlorpyriphos	20	6.25 lit/ha	26.9	28.7	2.1	6.4	77.6

* EIQ= Environmental Impact Quotient; EIQ-FUR= EIQ-Field Use Rating (Calculation is based on NYS IPM EIQ Database)

Table 3.6. Biological attributes of sugarcane adapted strain of *T. chilonis* (top borer strain)

Gene-ration	Mean ± S.Em					
	Longevity (days)	Fecundity	Adult emergence (%)	Female Emergence (%)	No. of male	Un-merged
F_1	2.5 ± 0.52	93.0±4.23	53.8±5.02	40.0±2.91	30.0±3.40	33.0±4.25
F_2	2.9 ± 0.79	72.29 ± 9.58	52.06 ± 6.69	55.83 ± 3.04	15.00± 0.95	38.86 ± 8.73
F_3	3.4 ± 0.83	89.50 ± 6.68	54.11± 3.60	41.89 ± 3.49	27.30± 2.12	32.50 5.50

(ii) **Pupal parasitoid, *Tetrastichus howardi* Olliff (wild strain)**

Wild strain of *T. howardi* was collected from pink borer pupae from the field and multiplied in the laboratory. The adult emergence/pupa of pink borer were 124 with 90 % female ratio. For further multiplication on pink borer, pupae (field collected strain) yielded more than 95% females in the successive generations in the laboratory and it also parasitised larvae of pink borer (10%). It acts as larval as well as pupal parasitoid in the field and laboratory conditions.

(iii) *Tetrastichus howardi* (Olliff) as hyper-parasitoid

As a primary parasitoid, *T. howardi* was collected from the larvae and pupae of pink borer, *Sesamia inferens* Walker. The larvae of pink borer were found parasitized by tachinid, *Sturmiopsis inferens* Townsend (larval parasitoid) (Fig.3.11). As hyperparasitoid, *T. howardi* was reared from puparia of Tachinid, *S. inferens*, a larval parasitoid which pupates outside its larval host (*Sesamia inferens*). When puparia of *S.inferens* was provided as a host for *T. howardi*, it was successfully parasitised in the laboratory and number of adults emerged as 54-56/puparia. This finding suggests that in the field condition, it act as hyper-parasitoid on puparia of *Sturmiopsis inferens*. (Fig.3.12).

Fig. 3.11 Parasitised pupa of top borer and emergence of *T. howardi*

(iv) *T. howardi* reared in jar on top borer pupa

Twenty-five top borer damaged shoots (with top borer pupae) was kept in glass jar and provided 25 females of *T. howardi* for parasitisation in BOD. After 10 days, shoots were splitted and pupae were kept individually in tube for further development of parasitoid. Out of 25 pupae, five pupae were found parasitised and emerged adults were healthy and active (Fig. 3.11). Survival of female was 11 days and it's fecundity in subsequent generations was improved. It is also found that 5th instar of top borer larva was found parasitised by *T. howardi*. (Fig. 3.13).

(iv) Biological attributes of pupal parasitoid, *T. howardi* on different host pupae

The development period (egg to adult) of *T. howardi* varied from 17.20 to 18.80 days in different host pupae (Fig. 3.14). The minimum period was

Fig. 3.12. Puparia of *Sturmiopsis inferens* formed on pink borer larva

Fig. 3.13 Parasitisation of puparia of *S. inferens* and adult emergence of *Tetrastichus howardi*

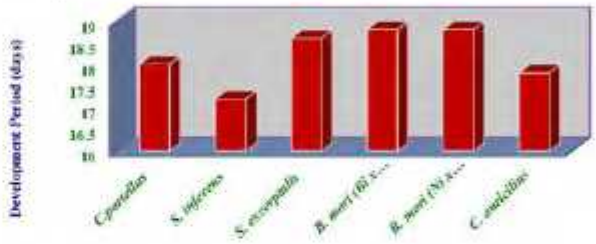


Fig. 3.14. Development period of *T. howardi* on different host pupae

observed in pink borer (17.20 days) and maximum (18.80 days) in pupae of mulberry silk worm (Ni x Bi and Bi x Bi strains). Variation in development period could be due to variation of the nutritional status of different host pupae on which the parasitoid was reared.

The mean number of progeny was observed (60.80 to 408.6) on various host pupae (Fig. 3.15). Progeny production/pupa was maximum on Bi x Bi strain (408.6) and minimum on stalk borer (60.80). The number of progeny was comparatively less on maize stem borer, top borer and stalk borer (less weighed pupa) than large weighed pupa (pink borer and mulberry silk worm (Bi x Bi & Ni x Bi strains). This may be attributed to the limitation of space and smaller pupa resulting in either lowering the fecundity of females or more mortality among immature stages or both. Maximum percentage of females emerged (96.10) from Ni x Bi strain of mulberry silk worm and pink borer (95.30) followed by maize stem borer, top borer, mulberry silk worm (Bi x Bi strain) (Fig.3.16).

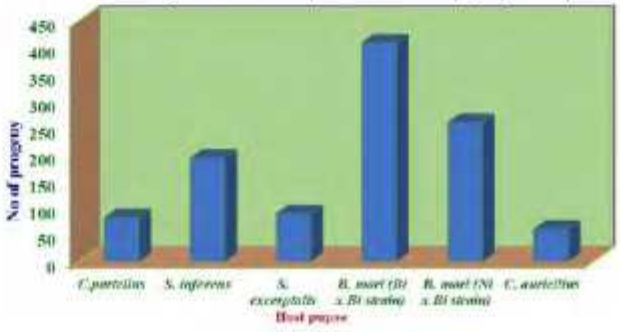


Fig. 3.15. Number of progeny/pupa of *T. howardi* on different host pupae

Female biased sex ratio (>90%) was observed in tested pupae. The sex ratio (Male : Female) varied from 1:12:.16 in Chilopartellus to 1:26.02 in mulberry silk worm (Ni x Bi strain). The minimum male emergence (3.90%) was observed in mulberry silk pupa (Ni x Bi strain) with maximum weight. Host size of pupa affects the sex ratio of the emerging progenies (Fig 3.17).

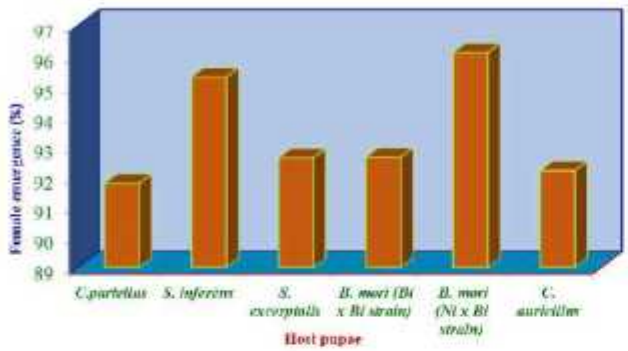


Fig.3.16 . Female emergence of *T. howardi* on different host pupae

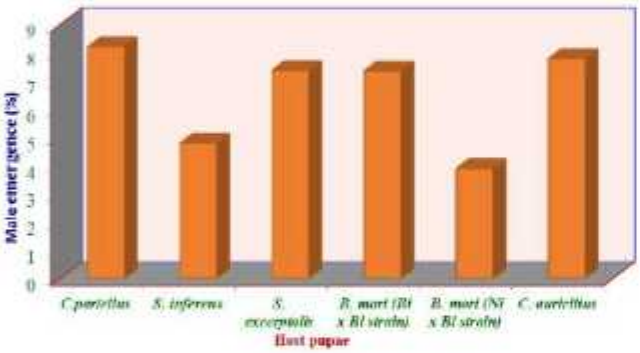


Fig. 3.17. Male emergence of *T. howardi* on different host pupae

VI Influence of adult nutrition on the biology of *T. howardi* on top borer female pupa

The life cycle of the parasitoid varied from 17.0 to 19.3 days in different nutrition regimes. Flower solutions of lantana and marigold with unfed supported fast development as compared to other nutrients. The availability of solutions of lantana, rose and chrysanthemum as a food source yielded maximum progeny (119.5-130.8/pupa) as compared to unfed (112.8), flower solutions of gladiolus (116.3) and marigold (106.0) (Table 3.7). The female progeny (>94%) was observed in all nutrition regimes along with unfed. The sex ratio (Male: Female) varied from 1:22 in flower solutions of chrysanthemum to 1:32 in rose.

Maintenance of natural population of insect-pests of sugarcane

Top borer, *Scirpophaga excerptalis*

The incidence of top borer (III & IV brood) and V brood was observed in standing sugarcane and at harvest, respectively. The most susceptible and least susceptible varieties for top borer (III brood) were Co 0238 and BO 91,CoLk 13204,CoLk 94184,CoC 671,CoS 767, respectively (Table 3.8). The lowest incidence (of IV brood was recorded in BO 91 (5.4%) followed by CoLk 11203 (7.6%), CoS 8436 (11.8%), Co 1148 (9.8%), Khakai (10.7%) and Co 7717 (11.6%) with highly susceptible was Co 0238 (39.03%). However, at harvest (V brood), the most susceptible variety was observed as CoLk 8102 followed by Khakai and CoLk 94184 and least susceptible as BO 91. Means followed by different letters in the same column are significantly different ($P<0.05$)

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

The observation of internode and stalk borer incidence was recorded in standing sugarcane in September and at harvest (December). The significantly highest incidence of internode borer was observed in Co 0238 (Standing) and CoLk 8102 (At harvest) with the lowest in Co S767, *Khakai*, Co1148 and CoC 671, *Khakai* in

Table. 3.7. Influence of adult nutrition on the biology of *T. howardi* on top borer female pupa

Nutrition (Flowers)	Weight of top borer pupa (gm.)	Development period (days)	No. of progeny/pupa	Female emergence (%)	Sex ratio (M:F)
Lantana	0.152^{c}	17.5^{a}	130.8^{b}	94.4^{a}	1:17.3
Marigold	0.145^{b}	17.3^{a}	106.0^{a}	95.8^{a}	1:24.0
Rose	0.136^{b}	18.0^{a}	119.5^{b}	96.1^{a}	1:32.0
Chrysanthemum	0.130^{a}	19.0^{a}	126.5^{b}	95.4^{a}	1:22.0
Gladiolus	0.117^{a}	19.3^{a}	116.3^{a}	95.7^{a}	1:22.6
Unfed	0.124^{a}	17.0^{a}	112.8^{a}	95.8^{a}	1:25.7

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

standing sugarcane and at harvest, respectively (Fig. 3.18).

The most susceptible variety was CoLk 13204 both in standing sugarcane and at harvest for stalk borer. Its incidence reached up to 74.7%. The least susceptible varieties were CoLk 11206, Co 767, *Khakai* in standing

Table 3.8. Incidence of insect-pests of sugarcane in different varieties

Variety	Incidence of different broods of top borer (%)		
	III	IV	V (at harvest)
CoS 767	8.7[a]	9.3[c]	6.0[b]
CoJ 64	14.7[c]	9.8[c]	10.7[d]
Co 7717	11.6[b]	11.1[d]	6.0[b]
CoC 671	8.7[a]	10.2[c]	8.7[c]
Khakai	10.7[b]	12.4[d]	22.7[g]
Co 1148	9.8[b]	10.2[c]	11.7[d]
CoLk 94184	6.5[a]	10.3[c]	18.7[f]
CoLk 13204	6.5[a]	9.7[c]	7.3[b]
CoS 8436	11.8[b]	13.1[d]	6.0[b]
CoLk 8102	18.5[d]	17.9[e]	26.7[h]
CoLk 11206	18.6[d]	11.6[d]	12.0[d]
Co 0238	21.0[e]	21.8[f]	15.3[e]
CoLk 11203	11.1[b]	7.6[b]	16.0[e]
BO 91	6.8[a]	5.4[a]	1.3[a]

sugarcane and CoS 8436 at harvest. The incidence of other borers (root and pink borers) was in traces.

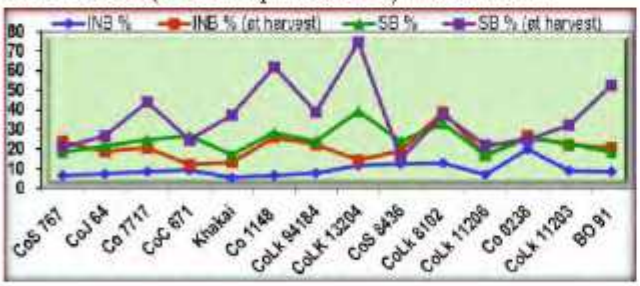


Fig. 3.18 Incidence of internode and stalk borer in different varieties of sugarcane

Evaluation of newer pesticides against insect-pests of sugarcane

Five new insecticides, namely chlorantraniliprole (18.5% SC), thiamethoxam (25%WG), clothianidin (50% WDG), imidacloprid (17.8%) and flubendiamide (39.35 SC) have been evaluated against sugarcane borers under field condition in RBD with three replications in each of the five treatments and control. The sugarcane variety Co 0238 was selected for this purpose. The mean per cent of incidence of top borer during III and V brood was at par with all the selected insecticides as in control. However, during IV brood, the per cent incidence was significantly lower with the treatment of chlorantraniliprole (4.07), thiamethoxam (7.53), clothianidin (2.40), imidacloprid (16.34) and flubendiamide (11.16) than control (17.76). In respect of incidence of internode and stalk borer, the mean values were at par with all treatments. The mean per cent of intensity was significantly lower with chlorantraniliprole (0.26) and imidacloprid (0.48) than control (0.73). However, the intensity was at par with thiamethoxam (0.89), clothianidin (1.01), flubendiamide (0.80) and control (0.73). The mean intensity of stalk borer in different treatments was at par control (0.80). The mean yield was the highest with imidacloprid (81.82 tonnes/ha) followed by clothianidin (81.06 tonnes/ha) chlorantraniliprole (71.97 tonnes/ha), flubendiamide (64.77 tonnes/ha), thiametoxam (64.39 tonnes/ha) against control (54.92 tonnes/ha).

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

A total of 77 germplasms were screened against red rot (plug method of inoculation), smut (complete inoculum load), wilt (sick plot) and Yellow Leaf Disease (natural condition) pathogen. Among all, five genotypes showed resistant (R), 43 moderately resistant (MR), five moderately susceptible (MS), 13 susceptible (S) and nine highly susceptible (HS) reactions against both the pathotypes (Cf 08 and Cf 09) whereas differential behaviour of two genotypes *viz.*, LG 17154 (MR to Cf 08 and MS to Cf 09) and LG 17256 (MR to Cf 09 and MS to Cf 08) was observed (Table 3.9). The screening against smut pathogen indicated 67 R, one MR, six MS, one S and two HS reactions under full inoculum load (Table 3.10). In addition, screening result of all genotypes against wilt pathogen (Sick Plot) indicated 58 R and 19 S reactions (Table 3.11). Whereas 69 and eight germplasms yielded R and S reaction respectively against YLD disease under natural crop condition (Table 3.12).

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

The study on effect of different Moist Hot Air Treatment (MHAT) on Yellow Leaf Disease (YLD) infected sugarcane *cv.* CoLk 94184 was undertaken with five different heat treatments in MHAT machine and planted during the crop season 2019-20. Ratoon crop of the same was raised and observations were recorded. The treatments were T_1 = 2h first day +2h second day +2h third day of MHAT at 50°C; T_2= 2h first day +1h second day +1h third day of MHAT at 50°C; T_3 = 2h first day +2h second day +1h third day of MHAT

Table 3.9. Reaction of genotypes against red rot pathogen (Cf 08 and Cf 09) through plug method of inoculation

R	MR	MS	S	HS
LG 15265, LG 17201, LG 17209, LG 17207 and II-28-17 **(Cf 08 and Cf 09)**	LG 16178, LG 16181, LG 16244, LG 15185, LG 15016, LG 15266, LG 15166, LG 15026, LG 15245, LG 16169, LG 17215, A-1, A-7, LG 15262, LG 16138, LG 15259, LG 17277, LG 17156, LG 17253, LG 17172, LG 17174, A-9, II-22-04, I-54-19, LG 17137, LG 17288, LG 17225, LG 17132, LG 17234, LG 17213, I-38-1, I-8-3, II-6-10, II-18-3, III-13-03, LG 17214, LG 17263, LG 17110, LG 17224, LG 17203, LG 17236, LG 17222 and II-10-18 **(Cf 08 and Cf 09)**	LG 16170, II-26-20, II-16-01, I-25-15 and LG 17219 **(Cf 08 and Cf 09)**	A-5, LG 17129, LG 17179, LG 17238, I-41-5RR, II-10-09, II-18-20, LG 15267, LG 17230, II-8-16, II-22-02, II-1-20 and II-16-20 **(Cf 08 and Cf 09)**	A-2, A-4, A-8, LG 17128, LG 17130, LG 17105, LG 17121, I-27-07 and II-24-03 **(Cf 08 and Cf 09)**
	LG 17154 **(Cf 08)**	LG 17154 **(Cf 09)**		
	LG 17256 **(Cf 09)**	LG 17256 **(Cf 08)**		

R-resistant, MR-Moderately resistant, MS-Moderately susceptible S-Susceptible, HS-Highly susceptible

Table 3.10. Reaction of genotypes against smut pathogen under complete inoculum load

R	MR	MS	S	HS
LG 16178, LG 16181, LG 16244, LG 15185, LG 15016, LG 15266, LG16170, LG 15265, LG 15166, LG 15026, LG 15245, LG 16169, LG 17215, A-2, A-4, A-5, A-7, A-8, LG 15262, LG 16138, LG 15259, LG 17128, LG17277, LG17156, LG 17179, LG 17130, LG 17253, LG 17172, LG 17174, A-9, II-22-04, I-41-5RR, II-10-09, I-54-19, II-26-20, II-18-20, LG 17137, LG 17105, LG 15267, LG 17225, LG 17132, LG 17121, LG17213, LG 17230, I-8-3, II-16-01, I-27-07, II-18-3, III-13-03, I-25-15, LG 17209, LG 17214, LG 17263, LH 17110, LG 17256, LG 17224, LG 17203, LG 17236, LG 17222, LG 17154, II-8-16, II-10-18, II-24-03, II-22-02, II-28-17, II-1-20 and II-16-20 **(67)**	LG 17288	LG 17238, LG 17234, LG 17201, I-38-1, II-6-10 and LG1 7207 **(6)**	LG 17219	A-1 and LG 17129

Table 3.11. Reaction of genotypes against wilt pathogen under sick plot conditions

R	S
LG 16178, LG 16244, LG 15016, LG 15266, LG 15265, LG 15166, LG 15026, LG 17215, A-1, A-2, A-4, A-5, A-7, A-8, LG 15262, LG 16138, LG 17128, LG 17277, LG 17179, LG 17130, LG 17253, LG 17238, LG 17174, A-9, II-10-09, II-26-20, II-18-20, LG 17137, LG 17105, LG 15267, LG 17288, LG 17225, LG 17121, LG 17234, LG 17213, LG 17230, LG 17201, I-38-1, II-6-10, II-16-01, I-27-07, II-18-3, III-13-03, I-25-15, LG 17209, LG 17214, LG 17110, LG 17256, LG 17207, LG 17224, LG 17203, LG 17236, LG 17222, LG 17154, II-24-03, II-22-02, II-1-20 and II-16-20 **(58)**	LG 16181, LG 15185, LG 16170, LG 15245, LG 16169, LG 15259, LG 17129, LG 17156, LG 17172, II-22-04, I-41-5RR, I-54-19, LG 17132, I-8-3, LG 17263, LG 17219, II-8-16, II-10-18 and II-28-17 **(19)**

Table 3.12. Reaction of genotypes against Yellow Leaf Disease of sugarcane under natural crop condition

R	S
LG 16178, LG 16244, LG 15185, LG 15016, LG 15266, LG 16170, LG 15265, LG 15166, LG 15026, LG 15245, LG 16169, LG 17215, A-1, A-2, A-4, A-5, A-7, A-8, LG 15262, LG 16138, LG 15259, LG 17128, LG 17129, LG 17277, LG 17179, LG 17130, LG 17253, LG 17238, LG 17172 , LG 17174, II-22-04, I-41-5RR, II-10-09, I-54-19, II-26-20, II-18-20, LG 17137 , LG 15267, LG17225, LG 17132, LG 17121, LG 17213, LG 17230, LG 17201, I-38-1, I-8-3, II-6-10, II-16-01, I-27-07, II-18-3, III-13-03, I-25-15 , LG 17209, LG 17214, LG 17263, LG 17110, LG 17219, LG 17256, LG 17207, LG 17224, LG 17203, LG 17236, LG 17222, LG 17154, II-8-16, II-10-18, II-24-03, II-28-17 and II-1-20 **(69)**	LG 16181, LG 17156, A-9, LG 17105, LG 17288, LG 17234, II-22-02 and II-16-20 **(8)**

at 50°C; T_4 = 1h first day +1h second day +1h third day and T_5 = Standard MHAT (54°C for 2 h 30 m) along with two controls (T_6 Healthy seed cane; T_7 Diseased seed cane). Sum total of six observations has been recorded each after 50 days intervals on visual basis. Results of serially heat-treated plant crop during 2019-20, revealed that that crop was healthy upto crop age of 150 days in all the treatment. While first symptoms (5% in T_4 and 8% in T_7) were noticed on 200 days old crop. The disease progressed with age in T_4 and T_7 as 10% and 15% at the age of 250 days. At this stage, disease was also observed in other treatments of MHAT (6% in T_2 and 5% in T_3). At the age of 300 days of crop, T_2, T_3, T_4, T_5 and T_7, recorded YLD infection as 11 %, 8% 13%, 5% and 22%, respectively. The disease progressed at the age of 350 days of crop and found as 13%, 13%, 15%, 08% and 38% in T_2, T_3, T_4, T_5 and T_7, respectively Among seven treatments, T_1 (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 from the seed cane. T_1 recorded 41.08 % germination 870 g single cane weight, 1.69 m cane length, 2.10 cm cane girth, 157.90 thousand millable cane with 137.37 tonnes yield per ha. The ratoon of said experiment was also monitored for the incidence of YLD and found that 250 days old ratoon recorded 8, 7, 12, 9 and 18 % infected clump in the treatment T_2, T_3, T_4, T_5 and T_7, respectively. At the age of 300 days old ratoon except T_1, all the treatments were found infected with 15, 10, 16, 2, 11 and 28% in T_2, T_3, T_4, T_5, T_6 and T_7, respectively. All the treatments were found infected at the ratoon age of 350 days (4, 21, 17, 23, 7, 14 and 50 clumps). The ratoon of T_1 recorded 810 g single cane weight, 145.91 thousand millable cane with 118.19 tonnes yield.

Identification of pathotypes in red rot pathogen

During 2020, 11 new isolates *i.e.* eight isolates from Co 0238 (IR-184, IR-185, IR-186, IR-187, IR-188, IR-189, IR-190 and IR-193); two isolates from CoS 8436 (IR-191 and IR-192) and one isolate from CoLk 8102 (IR-194) were evaluated for their virulence along with Cf 07, Cf 08 and Cf 09 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. Except Co 0238 isolates, the virulence pattern of other isolates more or less matched with the existing pathotypes of this zone. Co 0238 isolates showed intermediate reaction to BO 91, Co 7717, CoJ 64, Co 419, CoSe 95422, *Baragua* and *Khakai*; susceptible reaction to Co 975, Co 62399, CoC 671, Co 86002 and CoV 92102 and Co 0238 and resistance to CoS 8436, CoS 767, Co 997, Co 1148, Co 86032 and SES 594 which indicated the existence of gained virulence against BO 91, Co 975, Co 62399, Co 86002 and CoV 92102 and loss of virulence to CoJ 64, CoS 767, Co 997, CoS 8436, Co 1148, *Khakai* and Co 86032. The virulence pattern of Co 0238 isolates did not match with the designated pathotypes namely Cf 07, Cf 08 and Cf 09 of sub-tropical zone. Thus clearly indicating the existence of gained specific virulence of Co 0238 isolates on its host which is different from the existing pathotypes of this zone.

Evaluation of zonal varieties against red rot, smut and wilt

A total of six different trials with 45 varieties (7 IVT (early), 6 AVT (Early)-I Plant, 6 AVT (Early)-II Plant, 15 IVT (Mid-late), 5 AVT (Mid-late)-I and 7 AVT (Mid-late)-II Plant) was conducted and found differential behaviour to method of inoculation (Table 3.13).

Location: IISR, Lucknow (North West Zone)

Red rot

In AVT (Early), out of seven genotypes tested, one genotype CoPant 17221 was found susceptible (S) against both the pathotypes (Cf 08 and Cf 09) in both the method of inoculation (plug and nodal). Six genotypes *viz.*, CoLk 17201, CoLk 17202, CoLk 17203, CoPb 17211, CoPb 17212, CoPant 17221 and CoS 17231 were rated as moderately resistant (MR) by plug method and resistant (R) by nodal method of inoculation against both the pathotypes (Cf 08 and Cf 09)m (Table 3.13).

In AVT (Early)–I Plant, out of six genotypes tested,

one genotype namely CoLk 16201 was rated resistant (R) by both the method of inoculation (plug and nodal) against both the pathotypes (Cf 08 and Cf 09). Five genotypes *viz.*, CoLk 14201, Co 15025, Co 16029, CoLk 16202 and CoPb 16181 were rated as moderately resistant (MR) by plug method and resistant (R) by nodal method of inoculation against both the pathotypes (Cf 08 and Cf 09).

In Advanced Varietal Trial (Early)-II Plant, out of six genotypes tested, four genotypes *viz.*, Co 15023, Co 15027, CoLk 15201 and CoLk 15205 were rated as moderately resistant (MR) by plug method and resistant (R) by nodal method of inoculation against both the red rot pathotypes (Cf 08 and Cf 09). Two genotype Co 15024 and CoPb 15212 were rated moderately susceptible (MS) by plug method of inoculation and resistant (R) by nodal method of inoculation against both the red rot pathotypes (Cf 08 and Cf 09).

In Initial Varietal Trial (Mid late), out of fifteen genotypes tested, eleven genotypes *viz.*, CoLk 17204, CoLk 17205, CoPb 17215, CoPant 17223, CoS 17233, CoS 17234, CoS 17235, CoS 17236, CoS 17237, CoH 17261 and Co 17018 were rated moderately resistant (MR) by plug method of inoculation and resistant (R) by nodal method of inoculation against both the red rot pathotypes (Cf 08 and Cf 09). One genotype CoPb 17214 was rated as moderately susceptible (MS) against both the pathotypes (Cf 8 and Cf 09) by plug method of inoculation, whereas rated as resistant (R) by nodal method of inoculation against both the red rot pathotypes (Cf 08 and Cf 09). Two genotypes namely CoPb 17213 and CoH 17262 was found susceptible (S) by both the method of inoculationagainst both the red rot pathotypes (Cf 08 and Cf 09). One genotype, CoPant 17224 was rated as highly susceptible (HS) by plug method of inoculation and susceptible (S) by nodal method of inoculation against both the red rot pathotypes (Cf 08 and Cf 09).

In Advanced Varietal Trial (Mid late)-I Plant, out of five genotypes tested, one genotype CoLk 16204 was found resistant (R) by both the method of inoculation (plug and nodal) against both the red rot pathotypes (Cf 08 and Cf 09). One genotype Co 16030 was rated as moderately susceptible (MS) by plug method of inoculation and resistant (R) by nodal method of inoculation against both the red rot pathotypes (Cf 08 and Cf 09). The other three genotypes *viz.*, CoLk 16203, CoS 16232 and CoS 16233 were rated moderately resistant (MR) by plug method of inoculation and resistant (R) by nodal method of inoculation against both the red rot pathotypes (Cf 08 and Cf 09).

In Advanced Varietal Trial (Mid late)-II Plant, all the seven genotypes *viz.*, Co 15026, CoLk 15206, CoLk 15207, CoLk 15209, CoPb 15213, CoS 15232 and CoS 15233 were rated moderately resistant (MR) by plug method of inoculation and resistant (R) by nodal method of inoculation against both the red rot pathotypes (Cf 08 and Cf 09).

Smut

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

Out of 46 genotypes tested, 32 genotypes *viz.*, CoLk 17201, CoPb 17211, CoPb 17212, CoS 17231, CoLk 14201, Co 15025, CoLk 16202, CoPb 16181, CO 15023, Co 15024, Co 15027, CoLk 15201, CoLk 15205, CoPb 15212, CoLk 17204, CoLk 17205, CoPb 17215, CoS 17233, CoS 17234, CoS 17236, CoS 17237, CoH 17261, CoH 17262, Co 16030, CoLk 16203, CoLk 16204, CoS 16232, CoS 16233, Co 15026, CoPb 15213, CoS 15232 and CoS 15233 were rated as resistant (R) to smut.

Five genotypes namely CoPb 17214, CoPant 17223, CoS 17235, CoLk 15206 and CoLk 15207 were rated as moderately resistant (MR).

Seven genotypes *viz.*, CoLk 17202, CoPant 17221, Co 16029, CoLk 16201, CoPb 17213, CoPant 17224 and CoLk 15209 were rated as moderately susceptible (MS) against smut.

Two genotypes namely CoLk 17203 and Co 17018 were rated as susceptible (S) against smut of sugarcane whereas none of the genotype was found highly susceptible against the same.

Wilt

Out of forty six genotypes tested under natural infection condition (sugarcane wilt sick soil), thirteen genotypes *viz.*, CoLk 17202, CoPb 17211, Co 15025, Co 15024, Co 15027, Co 17214, CoPant 17223, CoS 17233, CoS 17234, Co S17237, Co 17018, Co 15026 and CoPb 15213 were rated as susceptible (S) to wilt disease of sugarcane.

Remaining thirty-three genotypes *viz.*, CoLk 17201, CoLk 17203, CoPb 17212, CoPant 17221, CoS 17231, CoLk 14201, Co 16029, CoLk 16201, CoLk 16202, CoPb 16181, Co 15023, CoLk 15201, CoLk 15205, CoPb 15212, CoLk 17204, CoLk 17205, CoPb 17213, CoPb 17215, CoPant 17224, CoS 17235, CoS 17236, CoH 17261, CoH 17262, Co 16030, CoLk 16203, CoLk 16204, CoS 16232, CoS 16233, CoLk 15206, CoLk 15207, CoLk 15209, CoS 15232 and CoS 15233 were found resistant (R) against wilt at IISR, Lucknow.

Yellow leaf disease (YLD)

Out of forty-six genotypes tested under natural infection condition, four genotypes *viz.*, CoLk 17202, CoPant 17223, CoPant 17224 and CoS 17233 were rated as susceptible (S) against YLD. Remaining forty-two genotypes were found resistant (R) to Yellow Leaf Disease.

Table 3.13. Reaction of zonal varieties against method of inoculation to both pathotypes of red rot (North-West Zone)

Trial		R Cf 08 and Cf 09	MR Cf 08 and Cf 09	MS Cf 08 and Cf 09	S Cf 08 and Cf 09	HS Cf 08 and Cf 09
AVT (Early)	Nodal	CoLk 17201, CoLk 17202, CoLk 17203, CoPb 17211, CoPb 17212, CoPant 17221 and CoS 17231	CoLk 17201, CoLk 17202, CoLk 17203, CoPb 17211, CoPb 17212, CoPant 17221 and CoS 17231			
	Plug		CoLk 17201, CoLk17202, CoLk 17203, CoPb 17211, CoPb 17212, CoPant 17221 and CoS 17231			
	Both				Co Pant 17221	
AVT (Early) -I Plant	Nodal					
	Plug	CoLk 14201, Co 15025, Co 16029, CoLk 16202 and CoPb 16181	CoLk 14201, Co 15025, Co 16029, CoLk 16202 and CoPb 16181			
	Both	CoLk 16201				
AVT (Early) -II	Nodal	Co 15023, Co 15027, CoLk 15201 and CoLk 15205		Co 15024 and CoPb 15212		
	Plug	Co 15024 and CoPb 15212	Co 15023, Co 15027, CoLk 15201 and CoLk 15205			
	Both					
IVT (Mid-late)	Nodal	CoLk 17204, CoLk 17205, CoPb 17215, CoPant 17223, CoS 17233, CoS 17234, CoS 17235, CoS 17236, CoS 17237 , CoH 17261 and Co 17018			CoPant 17224	
	Plug	CoPb 17214	CoLk 17204, CoLk 17205, CoPb 17215, CoPant 17223, CoS 17233, CoS 17234, CoS 17235, CoS 17236, CoS 17237, CoH 17261 and Co 17018	CoPb 17214		Co Pant 17224
	Both				CoPb 17213 and CoH 17262	
AVT (Mid-late) -I	Nodal	Co 16030 CoLk 16203, CoS 16232 and CoS 16233				
	Plug		CoLk 16203, CoS 16232 and CoS 16233	Co 16030		
	Both	CoLk 16204				
AVT (Mid-late) -I	Nodal	Co 15026, CoLk 15206, CoLk 15207, CoLk 15209, CoPb 15213, CoS 15232 and CoS 15233				
	Plug		Co 15026, CoLk 15206, CoLk 15207, CoLk 15209, CoPb 15213, CoS 15232 and CoS 15233			
	Both					

North Central Zone (IISR RC, Motipur)

In North Central Zone, 33 genotypes (Eight IVT (Early), 5 AVT (Early)-I Plant, 5 AVT (Early)-II Plant, 4 IVT (Mid-late), 4 AVT (Mid-late)-I Plant and 7 AVT (Mid-late)-II Plant along with standard checks) were screened against two red rot pathotypes (Cf 07 and Cf 08) by plug and nodal method of inoculation.

Red rot

In Initial Varietal Trial (Early), out of eight genotypes tested, seven genotypes *viz.*, CoSe 16454, CoP 17436, CoP 17438, CoP 17440, CoP 17441, CoSe 17451 and CoBln 17501 were moderately resistant (MR) by plug method of inoculation and resistant (R) by nodal method of inoculation against both the red rot pathotypes (Cf 07 and Cf 08). Genotype CoP 17437 was moderately susceptible (MS) by plug method of inoculation and susceptible (S) by nodal method of inoculation against both the red rot pathotypes (Cf 07 and Cf 08).

In Advanced Varietal Trial (Early)-I Plant, out of five genotypes tested, 4 genotypes *viz.*, CoP 16437, CoP 16438, CoLk 16466 and CoLk 16468 were rated as moderately resistant (MR) by plug method of inoculation and resistant (R) by nodal method of inoculation against both the red rot pathotypes (Cf 07 and Cf 08). Genotypes and CoSe 16451 was rated as moderately susceptible (MS) by plug method of inoculation and susceptible (S) by nodal method of inoculation against both the red rot pathotypes (Cf 07 and Cf 08).

In Advanced Varietal Trial (Early)-II Plant, all five genotypes tested *viz.*, CoLk 15466, CoLk 15467, CoP 15436, CoSe 15452 and CoSe 15455 were rated as moderately resistant (MR) by plug method of inoculation and resistant (R) by nodal method of inoculation against both the red rot pathotypes (Cf 07 and Cf 08).

In Initial varietal Trial (Mid-late), out of six genotypes tested, two genotypes *viz.*, CoSe 16456 and CoP 17446 were moderately resistant (MR) by plug method of inoculation and resistant (R) by nodal method of inoculation against both the red rot pathotypes (Cf 07 and Cf 08). Two genotypes, CoSe 16455 and CoP 17444 were moderately susceptible (MS) by plug method of inoculation and susceptible (S) by nodal method of inoculation against both the red rot pathotypes (Cf 07 and Cf 08). Genotype CoSe 17452 was moderately susceptible (MS) by plug method of inoculation and resistant (R) by nodal method of inoculation against both the red rot pathotypes (Cf 07 and Cf 08). Genotype CoBln 17502 was rated susceptible (S) by both method of inoculation against both the red rot pathotypes (Cf 07 and Cf 08).

In Advanced Varietal Trial (Mid-late)-I Plant, all four genotypes tested *viz.*, CoP 16439, CoLk 16470, CoSe 16452 and CoBln 16502 were moderately resistant (MR) by plug method of inoculation and resistant (R) by nodal method of inoculation against both the red rot pathotypes (Cf 07 and Cf 08).

In Advanced Varietal Trial (Mid-late)-II Plant, all the seven genotypes tested *viz.*, CoLk 15468, CoLk 15469, CoP 15438, CoP 15439, CoP 15440, CoSe 15453 and CoSe 15454 were moderately resistant (MR) by plug method of inoculation and resistant (R) by nodal method of inoculation against both the red rot pathotypes (Cf 07 and Cf 08).

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

Smut

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

Out of 35 genotypes tested, 20 genotypes *viz.*, CoSe 16454, CoP 17436, CoP 17437, CoP 17438, CoP 17440, CoBln 17501, CoP 16437, CoSe 16451, CoLk 15466, CoSe 16455, CoP 17444, CoP 17446, CoSe 17452, CoLk 16470, CoBln 16502, CoLk 15468, CoLk 15469, CoP 15438, CoP 15439 and CoSe 15454 were found resistant (R) against smut.

Ten genotypes *viz.*, CoSe 17451, CoP 16438, CoLk 16466, CoLk 16468, CoLk 15467, CoSe 15452, CoSe 15455, CoBln 17502, CoSe 16452 and CoSe 15453 were moderately resistant (MR).

Five genotypes *viz.*, CoP 17441, CoP 15436, CoSe 16456, CoP 16439 and CoP 15440 were moderately susceptible (MS) against smut.

Wilt

The incidence of wilt was recorded in the experiment conducted and results revealed that out of 35 genotypes tested, six genotypes *viz.*, CoP 17441, CoSe 17451, CoBln 17501, CoP 16438, CoBln 17502 and CoSe 15454 were susceptible (S) to sugarcane wilt.

Remaining 29 genotypes *viz.*, CoSe 16454, CoP 17436, CoP 17437, CoP 17438, CoP 17440, CoP 16437, CoLk 16466, CoLk 16468, CoSe 16451, CoLk 15466, CoLk 15467, CoP 15436, CoSe 15452, CoSe 15455, CoSe 16455, CoSe 16456, CoP 17444, CoP 17446, CoSe 17452,

CoP 16439, CoLk 16470, CoSe 16452, CoBln 16502, CoLk 15468, CoLk 15469, CoP 15438, CoP 15439, CoP 15440 and CoSe 15453 were resistant (R) against sugarcane wilt.

Yellow leaf disease (YLD)

Out of 35 genotypes tested, twelve genotypes *viz.*, CoP 17436, CoP 17440, CoSe 17451, CoSe 16455, CoP 17444, CoBln 17502, CoP 16439, CoLk 16470, CoP 15438, CoP 15439, CoP 15440 and CoSe 15454 were susceptible (S) against YLD.

Whereas remaining 23 genotypes *viz.*, CoSe 16454, CoP 17437, CoP 17438, CoP 17441, CoBln 17501, CoP 16437, CoP 16438, CoLk 16466, CoLk 16468, CoSe 16451, CoLk 15466, CoLk 15467, CoP 15436, CoSe 15452, CoSe 15455, CoSe 16456, CoP 17446, CoSe 17452, CoSe 16452, CoBln 16502, CoLk 15468, CoLk 15469 and CoSe 15453 were resistant (R) against YLD.

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

The survey has been conducted during sugarcane crop season of 2020-21 on commercial varieties in different cane growing area of Uttar Pradesh (IPL Sugar Chemical, Jarwal, Bahraich; Simbhaoli Sugar Mills, Chilwariya; KM Sugar Mills, Masaodha, Ayodhya; Command area of DSCL Group; Dalmia Chini Mill Group; Hargaon Oudha Sugar Mill; Seksaria Biswan Chini Mill, Biswan; Saraya Sugar Mills Ltd., Gorakhpur; Triveni Sugar Mill, Kushinagar and United Province Sugar Co. Ltd Kushinagar). Incidence of red rot was found associated in the varieties *viz.*, Co 0238, CoS 8436, CoS 767, CoS 92423, CoLk 08102, CoS 91269 and CoSe 95422.

- The variety Co 0238 was noticed with the infection of red rot at several location of Uttar Pradesh to the tune of 15 % to 80 %.
- Incidence of red rot was lower in other varieties *viz.*, CoSe 95422, CoS 8436, and CoSe 92423 up to 20 per cent.
- Incidence of smut was observed in Co 0238, CoSe 92423, CoS 88230 and CoS 91269.
- Incidence of GSD was noticed in most of the field surveyed (1-5%). In some locations, higher incidence of GSD was noticed in CoS 91269 (10-20%) and Co 0238 (5-10%).
- The incidence of the minor disease, Pokkah boeng was observed as major disease in most of the locations surveyed with the variety Co 0238. In some fields, Pokkah boeng incidence was noticed more than 30 per cent.
- The incidence of leaf scald was also noticed 2 to 10 %.
- The Yellow Leaf Disease was also observed in most of the location with the Variety CoLk 94184 and Co 0238.

In Bihar, Sasa Musa Sugar Mills, Gopalganj, New Swadeshi Sugar Mills, Narkatiaganj, West Champaran; Harinagar Sugar Mills Limited, Harinagar, West Champaran; Majhauliya Sugar Mills, West Champaran; command areas were monitored.

- CoLk 94184, Co 0118, Co 0238, CoP 06436, BO 91, BO 154, CoP 9301, CoSe 95422 and BO 130 were the varieties found in cultivation.
- Red rot was recorded in varieties namely Co 0238, CoSe 95422, BO 130 and CoP 06436.
- The variety Co 0238 was found infected with several diseases like red rot to tune of 15 to 60%; smut to the tune of 10-30%; Pokkah boeng to the tune of 15-40%; leaf scald to the tune of 5 to 20% and GSD to the tune of 2 to 10%.
- In general, it was noticed that incidence of GSD was found associated with most of the varieties of sugarcane at several locations. This will be alarming in future due to concomitant propagation of infected seed, if it not treated with MHAT.
- Yellow Leaf Disease (YLD) was noticed in the varieties *viz.*, CoSe 95422, CoP 06436, CoLk 94184, Co 0118, BO 130 and Co 0238.
- The incidence of wilt was observed 2 to 5% in the variety Co 0118 and BO 154 at few locations.

Assessment of elite and ISH genotypes for resistance to red rot

Twenty-four ISH genotypes along with two susceptible checks, CoJ 64 (for Cf 08) and CoS 767 (for Cf 09) were evaluated against red rot pathotypes Cf 08 and Cf 09.

- ISH 516 was resistant (R) against both the pathotypes (Cf 08 and Cf 09) by plug and nodal both the methods of inoculation.
- ISH 594 was highly susceptible (HS) against both the pathotypes (Cf 08 and Cf 09) by plug method of inoculation and susceptible (S) by nodal method of inoculation.
- ISH 542 and ISH 587 were susceptible (S) to both the pathotypes (Cf 08 and Cf 09) by plug and nodal methods of inoculation.
- Sixteen genotypes *viz.*, MR/MR- ISH 501, ISH 548, ISH 536, ISH 524, ISH 526, ISH 519, ISH 558, ISH 545, IGH 833, ISH 590, ISH 584, ISH 502, ISH 528, IGH 829, ISH 554 and ISH 567 were moderately resistant (MR) to both the pathotypes (Cf 08 and

Cf 09) by plug method of inoculation and resistant (R) by nodal method of inoculation.

- Two genotypes *viz.* ISH 585 and ISH 562 were moderately susceptible (MS) against the pathotype Cf 08 and moderately resistant against the pathotype Cf 09 by plug method of inoculation whereas rated as resistant (R) by nodal method of inoculation.
- Two genotypes *viz.* IGH 823 and IGH 834 were moderately susceptible (MS) against both the pathotypes of red rot (CF 08 and CF 09) by plug method of inoculation whereas rated as susceptible (S) by nodal method of inoculation.

ICAR-IISR Biological Control Centre, Pravaranagar (Maharashtra)

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

During 2020, surveys were conducted in the command area of Pravara, Korpewadi, Sanjeevani, Ashok, Sangmner and Rahuri Sugar Mills of Ahmednagar, Maharashtra, for the seasonal prevalence of diseases and pests in sugarcane. Incidence of brown spot disease ranged from 91.38% to 97.38%, rust disease incidence was reported in the range of 30-70% (Fig. 3.19 D & E) and infestation of white fly was observed in range of 25-75% (Fig 3.19 B). These severe occurrences were due to favourable climatic conditions during the season especially heavy rainfall and high relative humidity. Incidence 25-35% of YLD (Fig 3.19F) and infestation of sugarcane woolly aphids 10-30% (Fig 3.19C) was also recorded in surveyed area. Similarly, infestation of white grubs was sporadic in selected spot in the range of 40-80% (Fig. 3.19A).

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

Phytoplasma isolated from YLD infected sugarcane genotype CoS 510 (Acc. No. MN913611) is closely associated with the Sugarcane white leaf phytoplasma (SCWLP) which is known to cause white leaf disease in sugarcane. Moreover, the phytoplasma isolate originating from CoS 510 was closely related to the SCWLP-China isolate belonging to the 16SrXI-B subgroup of phytoplasma and shared 75% identity. Thus, it is concluded that the phytoplasma infecting sugarcane is more diverse and needs generation of sequence information of large number of phytoplasma isolates.

A total of twenty phytoplasma infected *Parthenium* samples were collected from five different surveyed fields with an incidence of 20% in 100 observed plants. The collected samples were categorized into four isolates based on the four types of symptoms observed in different fields (Fig. 3.20 A-D). The 16Sr RNA sequence information of first two *Parthenium* isolates (PPP-1: Acc. No. MT541822 and PPP-2: Acc. No. MT541823) were analyzed using

Fig. 3.19: The photographs of pest damages and diseases symptoms reported from sugarcane growing area of Ahmednagar, Maharashtra. A) White grub, B) White fly, C) Woolly aphid, D) Brown spot disease, E) Rust and F) Yellow leaf disease

EzTaxon database. The PPP-1 and PPP-2 *Parthenium* isolates showed 98.21% and 98.38% similarity with phytoplasma aurantifolia strain-WBDL (U15442), a reference strain belonging to 16SrII group. Moreover, the nucleotide (nt) sequence identity matrix using CLUSTAL W analyses of PPP-1 and PPP-2 showed 98% and 97% sequence identity, respectively with the '*Opuntia ficus-indica*' phytoplasma strain infecting Barbary fig in Italy (Acc. No. JQ181545) belonging to 16SrII-I subgroup (group: 16SrII; Peanut witches broom (WB) phytoplasma). Moreover, based on virtual restriction fragment length polymorphism (RFLP) profile of 16Sr RNA genes found the most similar reference pattern with the 16SrII group and I subgroup of phytoplasma (Acc. No. EU099551) (Fig. 3.20 E-F). However, the phylogenetic analyses of PPP-1 and PPP-2 *Parthenium* isolates revealed the close and distinct clustering with the same '*Opuntia ficus-indica*' phytoplasma strain (Acc. No. JQ181545) belonging to the 16SrII-I subgroup (Fig. 3.21).

Based on ExTaxon database analyses of third and fourth *Parthenium* isolates (PPP-3: Acc. No. MT541824 and PPP-4: Acc. No. MT541825) showed 99.02% and 97.79% similarity with the *Ca.* phytoplasma australasiae with *Caricapapaya* as a reference strain (AY10097) of 16SrII group. The nt sequence analyses of PPP-3 showed 95% identity and close clustering in phylogenetic tree with *Ca.* Phytoplasma aurantifolia (MK367414), infecting alfalfa (16SrII-D) reported from Iraq. Whereas, the nt sequence and phylogenetic analyses ofPPP-4 isolate revealed 98% sequence identity with *Ca.* phytoplasma aurantifolia (MK367414) infecting alfalfa (16SrII-D) and distinct clustering with other 16SrII-D subgroups of phytoplasma (Fig. 3.21), this subgroup is known to occur in *Parthenium* in India. The subgroup 16SrII-D is reported earlier Marathwada region of Maharashtra State in India, whereas the *Parthenium* isolates PPP-3 and PPP-4 from the present study showed the association of similar 16SrII-D subgroup were collected from Western Maharashtra in India (Fig. 3.20 G-H), therefore, its occurrence for the first time in this region. To the best of our knowledge, the natural infection of a 16SrII-I subgroup in *P. hysterophorus* is not yet reported so far. Therefore, findings from the present study, confirms the first report of association of 16SrII-I subgroup of phytoplasma related strain with *Parthenium*phyllody disease in India.

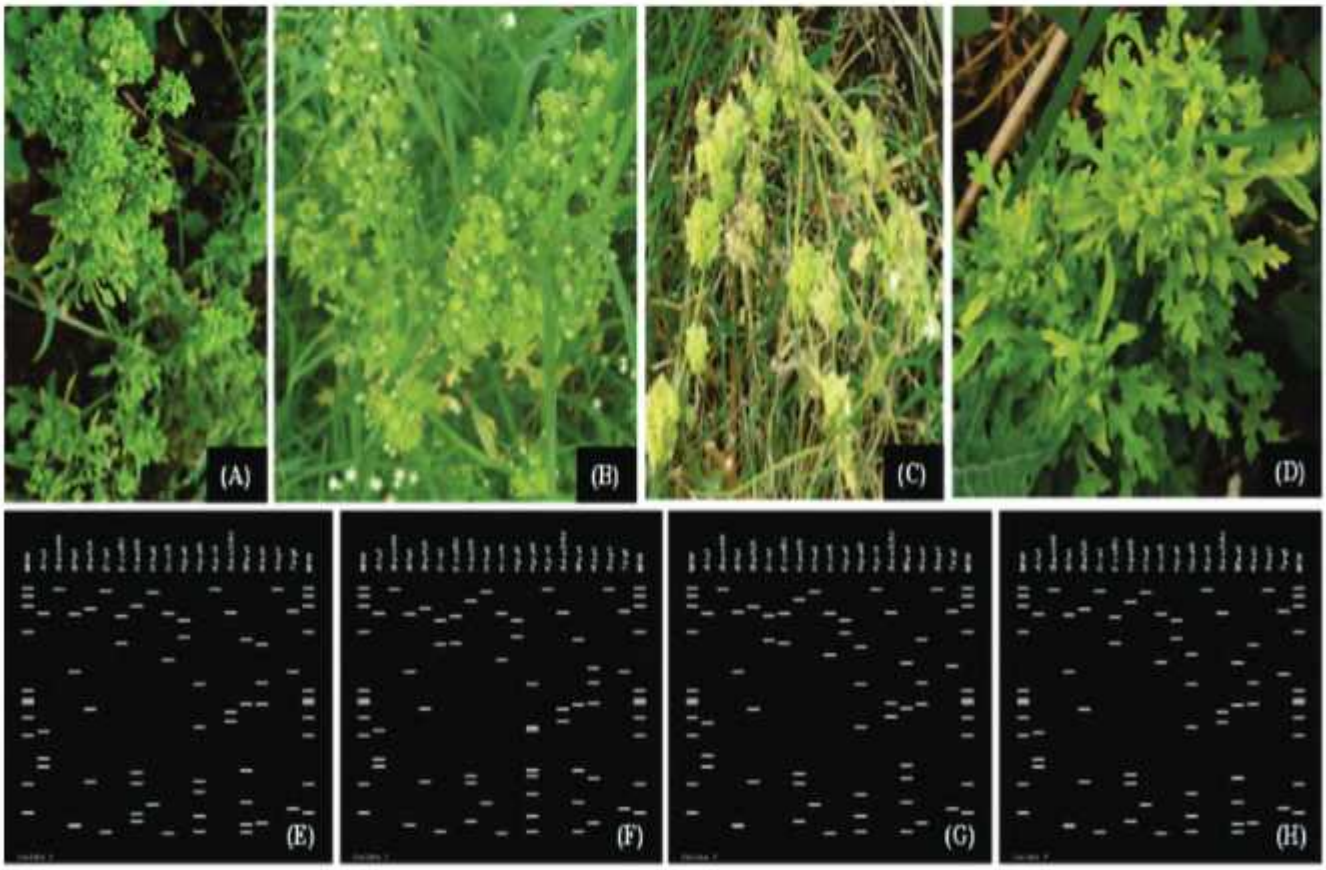


Fig. 3.20. Natural infection of phyllody phytoplasma in *Parthenium* plants characterized by different symptoms including witches broom like appearance (A), phyllody (B), yellowing with smaller leaves and bunching (C) and stunted growth (D). The virtual restriction fragment length polymorphism (RFLP) profile of the four phytoplasma isolates (E, F, G and H).

Figure 3.21. Phylogenetic tree based on evolutionary history of 16SrRNA gene sequences of four *Parthenium* phytoplasma isolates was inferred using the Neighbour-Joining method with the available phytoplasma strains in the NCBI GenBank.

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

The nine isolates of entomopathogenic bacteria causing milky disease in white grubs were isolated from diseased grubs collected from white grub infected sugarcane field Lohgaon, command area of PDVVPSK Ltd, Pravaranagar. Similarly, the six isolates of spore forming entomopathogenic bacteria were isolated from dead cadaver of *Galleria mellonella*. The milky disease bacterium, Paenibacillus spore gemination and optimum vegetative growth was observed on J medium at 30°C (Figure 3.22a, b). The inoculation of *in vivo* and *in vitro*, produced spores of *Paenibacillus* sp by injection and ingestion were unable to produced disease symptoms in field collected 2nd and 3rd instar white grubs under laboratory conditions. The *Bacillus thuriengensis* and *Brevibacillus* sp strains isolated from sugarcane rhizosphere not shown any insecticidal activity against 1st, 2nd and 3rd instar white grubs.

Utilization of entomopathogenic nematodes against white grubs

The indigenous strains of EPN were isolated from the soil samples collected from sugarcane field of CoM 265 and Co 86032 from Pravaranagar and Kolhapur area of Maharashtra using Galleria-baited technique (Fig 3.23a, b). The 18S sequence analysis revealed that the EPN isolate of Pravaranagar were identified as *Heterorhabditis indica* and these isolates was designated as IISRBCCH02 and IISRBCCH03. Studies on survivability and infectivity EPN isolates to different levels of temperature ranges indicated that *H. indica* IISRBCCH02 IJs were survived at temperature range between 15°C and 30°C, although penetration of IJ was increased up to 35°C, the reduction in viability, longevity and rate of infection was observed beyond 35°. Similarly, *H. indica* IISRBCCH03 IJs were survived at temperature range between 15°C and 35°C, although penetration of IJ was increased up to 35°C, the reduction in viability, longevity and rate of infection was observed beyond 35°C. Pathogenicity studies of *H. indica* IISRBCCH02 revealed that the 150 and 300 IJs per grub were sufficient to kill early and late larval instars of white grub after 3 to 5 days upon EPN inoculation (Fig 3.23d). The *Photorhabdous* sp from EPN infected Galleria cadaver were isolated, purified and axenic cultures were sent for molecular identification (Fig 3.23c).

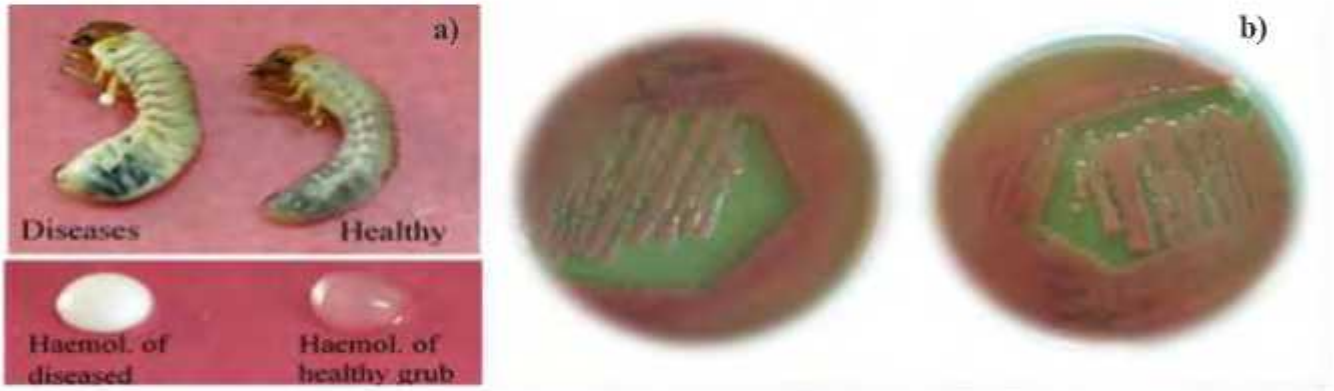


Figure 3.22 a) Milky diseased grubs of *Holotrichia* sp. Left: Diseased grubs and Right: Healthy grub; b) Culture plates of milky disease bacterium *Paenibacillus* sp.

Figure 3.23. Soil baiting with Galleria for EPN isolation a) Reddish/brown coloured dead Galleria cadavers spotted in soil samples; b) Modified White trap for the emergence of infective juveniles (IJs) from EPN killed Galleria cadavers; c) MacConky agar plates of a bacterium *Photorhabdous* sp isolated from Galleria cadaver infected with EPN and d) EPN killed early instars of white grub

RKVY Funded Project: Establishment of Biological Control Laboratory for mass production of bio-agents against insect-pest and diseases and dissemination of technology for enhanced cane and sugar productivity of Maharashtra (₹ 5 crore)

Under the RKVY scheme, the Govt. of Maharashtra approved and sanctioned the project during 23rd State Level Sanctioning Committee (SLSC) meeting under the Chairmanship of Chief Secretary, Govt. of Maharashtra. land-lease registration document, land-lease deed MoU with sugar mill, *Gav Namuna Sat* 7/12, plot demarcation certificate, and other required documents were submitted to RKVY Office, Pune. The architectural plan, section and elevation of the Biological Control Laboratory have been finalized. The funds demand letter has been submitted to the Director. Planning & Processing, RKVY Cell, Pune for release of first instalment.

CHAPTER 4

Research in Plant Physiology and Biochemistry

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

Impact of PGRs on sugarcane ratoon crop

The ratoon crop was initiated in February 2020 from the plant crop with two doses of GA_3, IBA, 6BA and NAA each along with water, *Ethrel* and absolute control using CoLk 94184. During the crop cycle, initial plant numbers, tiller numbers and biomass accumulation indicated that maximum improvement in sprouting and biomass dynamics occurred with *Ethrel* as compared to water and control. The sprouting % was in decreasing order of *Ethrel* @ 100 ppm > NAA @ 50 ppm > NAA @ 100 ppm > 6BA @ 50 ppm, 6BA @ 100 ppm > IBA @ 50 ppm > IBA @ 100 ppm >water >control at 120 DAP. Average initial shoot numbers were highest with *Ethrel* (1,80,131 shoots/ha) followed by NAA @ 50 and 100 ppm at 180 DAP with 1,43,431 and 1,37,631 shoots/ha, respectively against 1,22,907 shoots/ha with water. The biomass accumulation followed the similar trend at 270 DAP. *Ethrel* surpassed biomass accumulation against all compounds at all concentrations. Tiller numbers/ha were in order of 1,76,029, 1,31,506, 1,69,142 with *Ethrel* @ 100 ppm, NAA @ 50 & 100 ppm against 1,15,906 & 1,20,507 with control and water, respectively. Number of millable canes (NMC)/ha, single cane weight (g) and cane yield (t/ha) indicated maximum effect of *Ethrel* followed by NAA @ 50 & 100 ppm with 1,27,962, 1,14,629, 96,981 NMC/ha against 97,037 and 85,370 NMC/ha in water and control, cane weight 606, 531, 527 g against 580 and 520 g in water and control and cane yield 77.51, 51.23, 60.40 t/ha against 56.28 and 44.39 t/ha in water and control, respectively at harvest.

Impact of PGRs on sugarcane plant crop

A field experiment was initiated in Feb 2020 with two doses of GA_3, IBA, 6BA and NAA each along with water, *Ethrel* and absolute control using CoLk 94184. During the crop cycle, tiller numbers and biomass accumulation till 210 DAP indicated that maximum improvement in germination and biomass dynamics occurred with *Ethrel* as compared to water and control. The germination % was in decreasing order of *Ethrel* @ 100 ppm >NAA @ 50 ppm > NAA @ 100 ppm > water> control at 90 DAP. Average initial shoot numbers were the highest with *Ethrel* (1,48,816 shoots/ha) followed by NAA @ 50 and 100 ppm at 120 DAP with 1,32,415and 1,23,865 shoots/ha, respectively against 98,817 shoots/ha with water. The biomass accumulation pattern remained same till 180 DAP. Biomass accumulation was highest in *Ethrel* against all compounds at various concentrations. Tiller numbers/ha were 1,80,816, 1,51,581, 1,31,816 with *Ethrel* @ 100 ppm, NAA @ 50 & 100 ppm against 1,33,441 with water at 180 DAP . Other biometric traits *vis a vis* cane length , girth, internodal numbers, internodal weight, number of roots, root length, number of root hairs and cane weight showed similar trends with maximum impact of sett soaking with *Ethrel* followed by NAA @ 50 and 100 ppm till 240 DAP. Number of millable canes (NMC)/ha, single cane weight (g) and cane yield (t/ha) indicated maximum effect of *Ethrel*,followed by NAA @ 50 & 100 ppm with 1,47,620, 1,30,03, 1,39,597 against 1,20037 in water, single weight (g) 620, 531, 560 against 562 in water and cane yield (t/ha) 91.52, 69.51, 78.17 against 67.40 t/ha in water, respectively at harvest.

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

Post-harvest deterioration of cane quality was assessed using two sugarcane varieties (CoLk 94184 and CoLk 09204). and January. Autumn planted cane was used for the study. Both control and BKC+SMS treated canes were assessed for Brix % and change in the level of reducing sugar (%) at zero, 2, 4, 8 days after harvest. Chemical formulation was applied after taking the observation at zero days. Results, based on change in the level of reducing sugar indicated that variety CoLk 09204 was more susceptible to post harvest losses in comparison to CoLk 94184 (Fig. 4.1). Reducing sugar increased significantly when cane was not exposed to chemical formulation and this increase was more in CoLk 09204. Till 4 days of harvest, change in both Brix and reducing sugar was not much, presumably due to low ambient temperature. Response of chemical formulation towards checking inversion of sucrose to reducing sugar was more in CoLk 09204 (38%) than of CoLk 94184 (26%) when difference in level of reducing sugar was measured on 8th day of post harvest (Fig. 4.1).

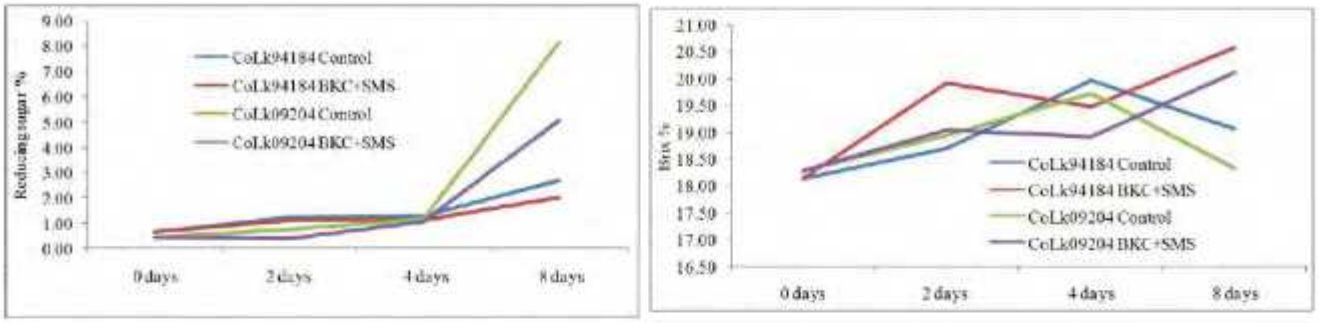


Fig. 4.1. Change in reducing sugar and Brix measured at different days after harvest of the canes. Treatment (0.2% BKC + 0.1% SMS) was given after harvest of the cane.

Genome sequencing of red rot pathogen of sugarcane

The analysis of the whole genome sequence of virulent pathotype (*Cf* 08) of *C. falcatum* causing red rot on sugarcane (Table 4.1) revealed, 617 CAZymes and of these glycoside hydrolases were the predominant (298). Among 7264 genes associated with pathogenicity/virulence, 77 genes having effector functions were identified (Table 4.2). The assembled genome showed its similarity with the genome of *C. graminicola* and *C. higginsianum*, the causal organisms of anthracnose in maize and in members of *Brassicaceae*, respectively. A total of 94 large sequences (>100 Kb) of *Cf* 08 were mapped over *C. higginsianum* 10 of 12 chromosomes with 106 synteny blocks (Fig. 4.2). Results provided the opportunity to further study the evolutionary and functional genomics in *C. falcatum*.

Table 4.1 Assembly and annotation statistics of *C. falcatum Cf* 08 estimated using QUAST and *C. falcatum Cf* 671 genome

Assembly statistics	*C. falcatum Cf* 08
Sequencing platform	PacBio SMRT
Genome size (bp)	56062448
Total sequence bases	~7.24Gb polymerase read data/ ~5.21Gb filtered read data (242298 reads)
Coverage	124×
Number of contigs	238
Size of the largest contig (bp)	2232291
N50 (bp)	506431
N75 (bp)	317938
L50	34
L75	72
GC content (%)	54.14
#N's per 100kbp	0
Annotation statistics	
Number of protein coding genes	18,635
Predicated effectors	77
Predicted number of CAZymes	617

Table 4.2 Summary of predicted genes exhibiting homologies with known functions, pathogenicity genes, CAZyme genes and enzyme classes identified from the *C. falcatum Cf* 08 genome assembly

Category	Number
Total protein coding genes	18,635
Predicted genes exhibiting homologies with known functions in:	
NCBI non-redundant database	10,013 (53.73%)
GO data base	8,289 (44.48%)
KEGG data base	8,602 (46.10%)
Predicted genes associated with fungal pathogenicity and virulence (PHI-database)	7,264
Antimicrobial resistance (AMR) genes	39
CAZymes	617
Glycoside hydrolase (GH)	298
Carbohydrate esterase (CE)	45
Polysaccharide lyase (PL)	17
Auxiliary activities (AA)	95
Carbohydrate-binding module (CBM)	9
Glycosyl transferase (GT)	153
Enzyme classes (Sequence)	
Oxidoreductases	551
Transferases	698
Hydrolases	949
Lyases	211
Isomerases	87
Ligases	164

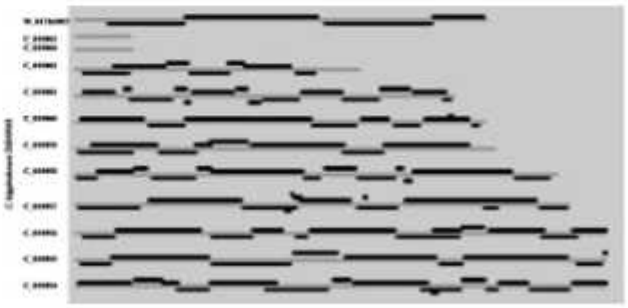


Fig. 4.2 Mapping of 94 sequences from *C. falcatum* (*Cf* 08) over *C. higginsianum* (10 of 12 chromosomes) with 106 synteny blocks, depicting co-linearity between *C. falcatum* and *C. higginsianum*

Physiological and molecular bases of multiple abiotic stress tolerance in sugarcane

Experiments in field and pots were conducted to

elucidate physio-molecular traits conferring single/multiple abiotic stress tolerance in sugarcane. In field trial, eleven genotypes (CoLk 94184, BO 91, CoS 767, CoJ 64, CoLk 12204, CoLk 07201, LG 04439, LG 03040, A-46-11, A-27-12 and UP 9530) were evaluated for drought tolerance. On the basis of relative cane weight, A-27-12 followed by CoLk 94184, CoLk 12204 and CoS 767 were identified as the most drought tolerant genotypes. Drought caused a significant reduction in internode length of genotypes. There was a significant correlation between drought tolerance and internode length; the genotypes with higher internode length under drought showed higher drought tolerance (Fig 4.3). Drought caused an increase in root density of all genotypes; compared to control,the highest increase in root tissue density was found in A-46-11 followed by CoLk 94184 and CoS 767. In pot experiment, measurement of gas exchange traits indicated significant decrease in photosynthetic rate and stomatal conductance of varieties CoS 767 and CoJ 64 under single/multiple abiotic stress. CoS 767 exhibited higher photosynthetic rate and stomatal conductance than CoJ 64 under all stresses (drought, waterlogging) except for salinity. Compared to control, there was a decrease in canopy temperature depression under all stresses. At 120 DAP, the highest canopy temperature depression was observed under drought in both CoS 767 and CoJ 64, whereas, at 180 DAP, the highest canopy temperature depression was observed under drought+ waterlogging+ salinity in both the varieties. As a measure of root membrane integrity, root electrolyte leakage was determined under different stresses. At 120 DAP, the highest electrolyte leakage was observed in drought + salinity for both the varieties; CoS 767 had relatively lower electrolyte leakage than CoJ 64. At 180 DAP, highest electrolyte leakage was found in drought + waterlogging + salinity, where sensitive variety (CoJ 64) had higher electrolyte leakage than tolerant variety (CoS 767). The leaf tissue K concentration of CoS 767 and CoJ 64 dropped below the critical deficiency level (0.90%) under single/multiple abiotic stresses; the highest decrease in leaf tissue K concentration in both the varieties was recorded under drought + waterlogging + salinity where CoS 767 maintained better level of leaf K than CoJ 64 (Fig. 4.4). A significant positive correlation (R^2=0.751) existed between leaf tissue K concentration and stress tolerance of varieties. These findings suggest that maintenance of better level of leaf K concentration under stresses can be an important selection criterion for multiple abiotic stress tolerance.

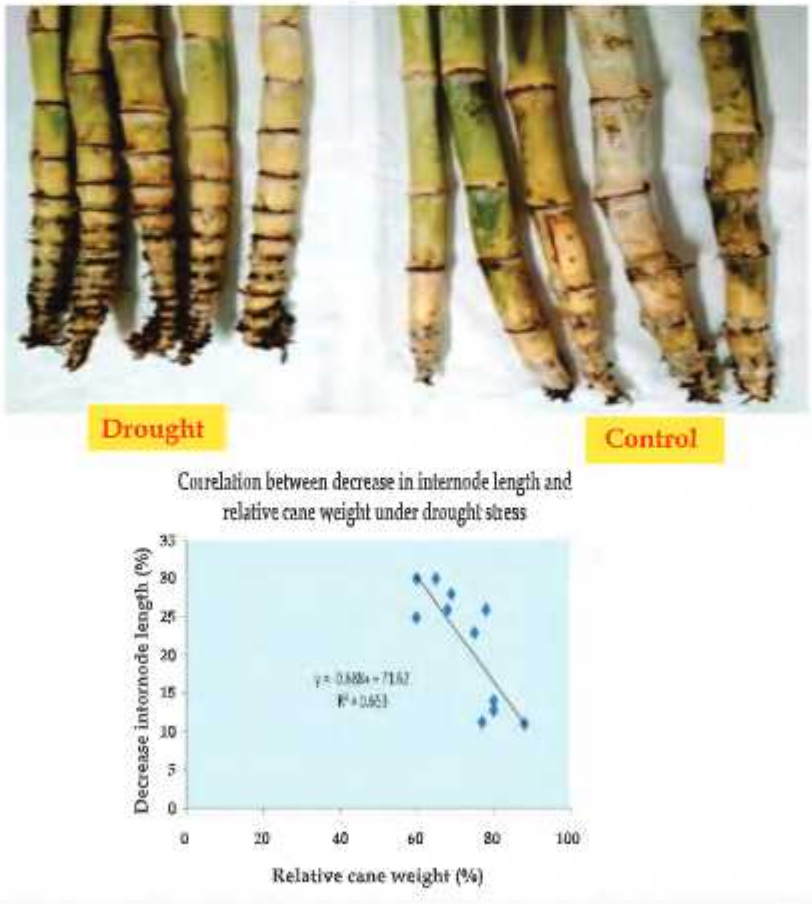
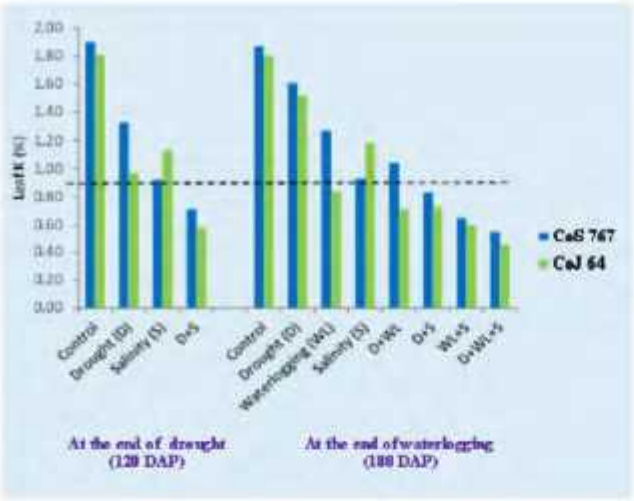
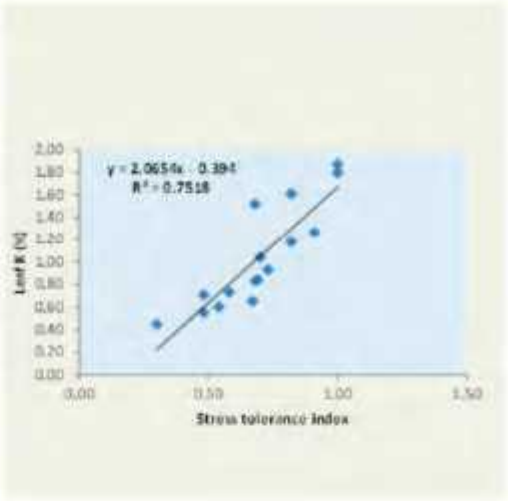


Fig. 4.3. Decrease in internode length of sugarcane genotypes and its relation with relative cane weight under drought stress



Dash line above bar show the critical deficiency level of K in sugarcane (0.90%), McCray and Mylavarapu (2010)



Correlation between leaf K (%) and stress tolerance index

Fig. 4.4. Leaf tissue K content of CoS 767 and CoJ 64 under different stresses

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 their photosynthetic attributes and water use efficiency (WUE) at 180 DAP (Fig 4.5). Maximum photosynthesis rate was recorded in BO 91 (23.9 µmol m^{-2} s^{-1}) which was at par with CoLk 8102 (22.6 µmol m^{-2} s^{-1}), while, transpiration rate was maximum and at par with CoLk 9709 (12.8 mmol m^2/ s) and CoLk 8001 (12.2 mmol m^2/s). Instantaneous and intrinsic leaf water use efficiency was also calculated and significant variations was observed among sugarcane genotypes. Instantaneous leaf WUE of BO 91 was maximum (2.8 µmol/mmol) and was at par with Co 0238 (2.6 µmol/mmol), CoLk 94184 (2.5 µmol/mmol) and CoLk 11206 (2.3 µmol/mmol). Minimum value for instantaneous leaf WUE was recorded in CoLk 9709 (0.8 µmol/mmol). Similar trend was recorded for intrinsic leaf WUE. Significant variations was observed for chlorophyll (Chl) content among sugarcane varieties tested. Total chlorophyll content was the lowest in CoJ 64 (1.08 mg/g fwt) and maximum in CoLk 94184 (2.8 mg/g fwt). Minimum Chla (0.8 mg/g fwt) and Chl b (0.2 mg/g fwt) content was observed in CoJ 64, while, maximum in CoLk 94184 (Chl a 2.2 mg/g fwt) and Chl b in BO 91 (0.5 mg/g fwt). Maximum relative water content was observed in Co 5011 (98.1%) followed by CoLk 9707 (94.7%) which was at par with BO 91 (92.4%) and Co 0238 (93.5%).

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

Effect of silica on spring planted sugarcane variety CoLk 11206 (mid-late) was studied. Application of silica was executed in two forms *i.e.* silicic acid and silicon dioxide at the rate of 100 and 200 kg of Si/ha as basal dosage and foliar application of both silica forms were done at 90 and 120 DAP at the rate of 14 g/l of Si. Silica, when applied at 200 kg Si/ha as silicic acid as basal dose, recorded significantly higher germination (23%) as compared to control (19.5%) indicating a possible role of available form of silica on plants. Sheath and root dry weight also improved in silica treated plants. Further, it was found that silica treatments improved germination of buds, root and sheath weight, thus, providing hardiness to the plants enabling some resistance against disease and pest attack. Juice quality attributes did not reveal any significant change under silica treatment.

Photosynthetic pigments such as chlorophyll and carotenoids contents were not influenced significantly with silica, however, photosynthesis, stomatal conductance and transpiration rate was significantly varied. Maximum photosynthesis (16.2 µmol/m^2/s), transpiration (4.4 mmol m/s) and stomatal conductance (0.12 mol m^2/s) was recorded when silica (200 kg/ha) was applied in the form of silicic acid as basal dose (Fig 4.6).

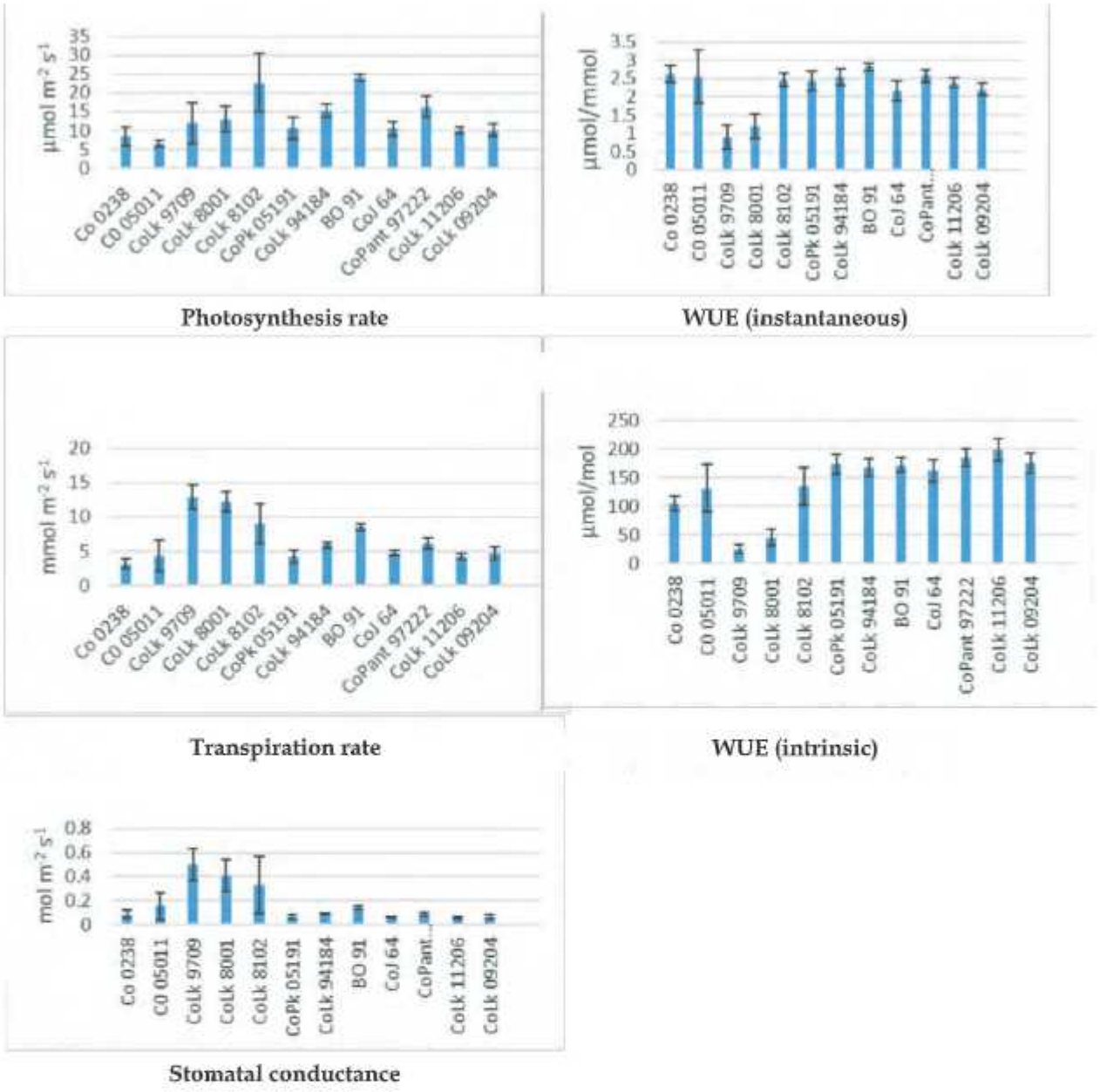


Fig 4.5 Gaseous exchange parameters (photosynthesis, transpiration and stomatal conductance) and WUE (instantaneous and intrinsic) in sugarcane varieties recorded at 180 DAP

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

Usage of sugarcane trash (SCT), a low cost lignocellulosic material formed by three main fractions (cellular, hemicellulose and lignin) is a source of ecological and economic advantage. The raw material was processed and fractions of particles with size lower than 0.5 mm were homogenized and stored. SCT was subjected to various acid hydrolysis. Phosphoric acid hydrolysis with 1, 3, 5 & 7% concentration in a slurry containing SCT/water ratio (SWR) of 1 g SCT/10 ml water on dry basis at 125°C offered maximum fermentable sugars (FS). The reactions times ranged 0-240 mins from under phosphoric acid concentrate. The supernatant subjected to separation, contained glucose, xylose and arabinose. The pellets determined the solubilized fraction on dry basis. The sugar concentrations were the highest for xylose, arabinose and glucose at 4% acid concentration at 240 min. The pentose's (xylose + arabinose) concentration (P) and total sugars (arabinose + glucose + xylose) concentrations (S) increased with acid concentration and reaction times (Fig 4.7). At lower reaction times (60 min), higher was the acid concentration, lower was the release of S. It was also observed that most drastic conditions led to severe decline in P and S concentrations. Maximum concentration were obtained with 6% acid (20.1 g pentose /L and 25.4 g sugars/L) at 240 min.

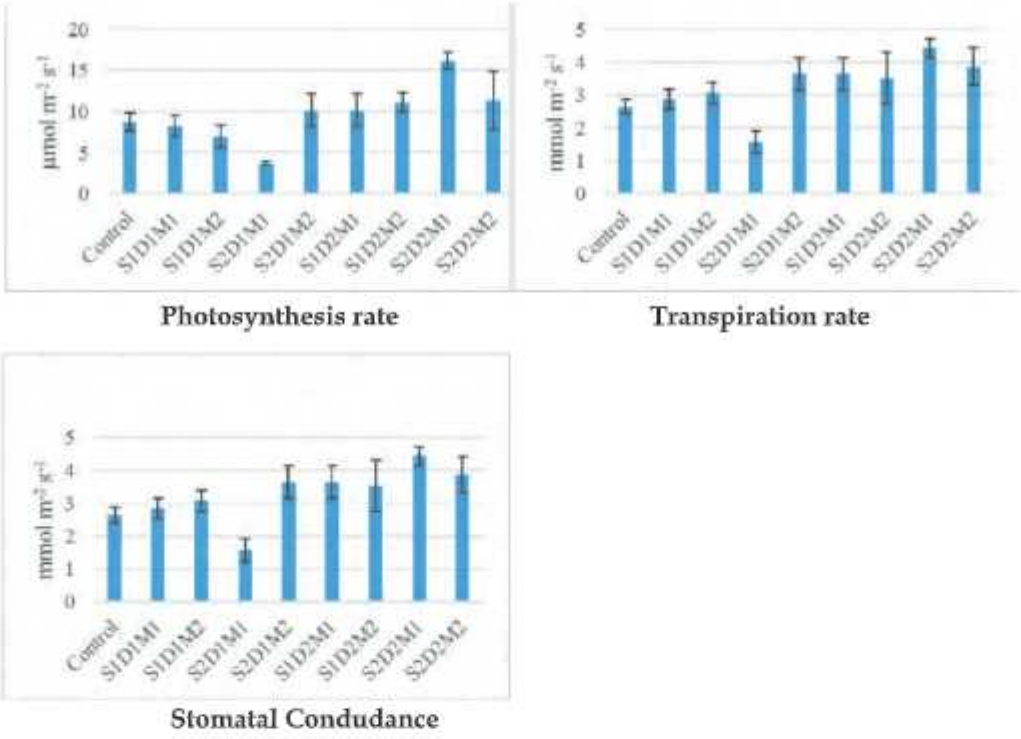


Fig. 4.6 Effect of silica on photosynthesis, transpiration and stomatal conductance of sugarcane. (S1=Silicon dioxide; S2=Silicic acid; D1=100 kg Si/ha; D2=200 kg Si/ha; M1= Soil application; M2= Foliar application @90 and 120 DAP)

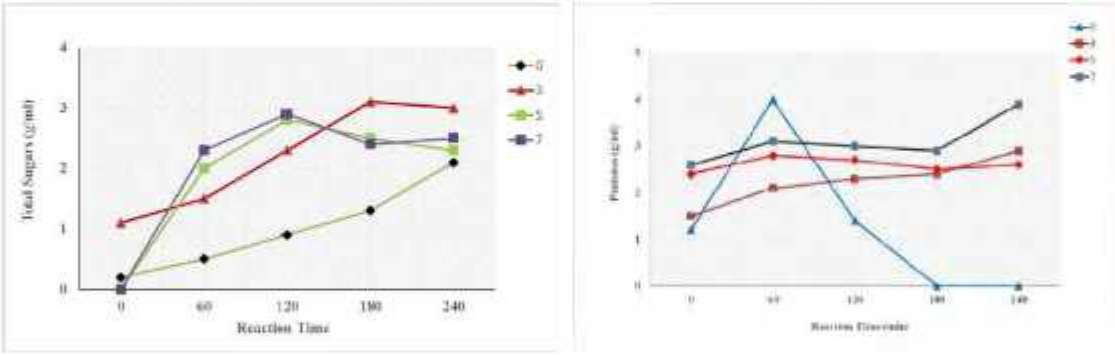


Fig 4.7. Fermentable sugars from chemical pre-treatment of SCT

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

Transcriptome analysis of sensitive and resistant waterlogging lines

Comparative transcriptome analysis was performed using leaf samples of both control and waterlogged plants of two genotypes *viz.* CoLk 94184 (tolerant) and CoJ 64 (sensitive). Total PE reads were 3,62,92,012, 3,40,08,354, 3,50,79,347 and 4,44,66,851 in leaves of control, & waterlogged plants of variety CoLk 94184 and CoJ 64 variety, respectively.

Biochemical analysis Analysis of leaf chlorophyll content demonstrated that under non-stress (NS) condition, chlorophyll content ranged between 1.59 and 2.91 mg/g fwt (in control) and 1.35 and 2.71 mg/g fwt in waterlogged plants suggesting decline in leaf photosynthesis due to waterlogging.

Metagenome analysis: Microbial diversity of rhizosphere soils collected from waterlogged and control plots based on 16S rRNA gene: Out of total 1,54,420 representative sequences used for taxonomic classification; 1,53,066 sequences were clustered as Operational Taxonomic Units (OTUs). Total number of OTUs picked were 1,53,066 out of which 91-92% were classified under Kingdom Bacteria in waterlogged and 94% in control plots and 6- 9% from four samples were assigned to unknown species.

CHAPTER 5

Mechanization of Sugarcane Farming

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

Tractor operated two row disc type ratoon management device was developed for carrying out 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- to perform off barring and fertilizer application. The second prototype has stubble shaver attachments also to perform stubble shaving along with off barring and fertilizer application (Fig. 5.1). Prototype without stubble shaver is suitable for piecemeal harvesting. Field trials were conducted at IISR farm as well as farmers field at Hardoi to evaluate the performance of the developed machine. Effective field capacity of the machine was 0.30 - 0.35 ha/h.

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

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

Prototype of developed multipurpose tool frame with attachments for furrow opening, interculturing and earthing up was demonstrated at farmers' field in more than 6.0 ha area in Biswan Sugar mill. The machine has provision for adjustments for cane planted at 75 or 90 cm row spacing. The IISR deep furrowers were used as an attachment for furrow opening and earthing up operations (Fig. 5.2). The interculturing attachment having tines with shovel and sweep were

Fig. 5.2. Demonstration of multipurpose tool frame for earthing up operation at farmer's field

used for inter-row interculturing (Fig. 5.3). The capacity of the machine was 0.45 ha/h for inter-row interculturing with 76% field efficiency. The demonstration for earthing up operation was also carried out using three furrowers to cover three rows at

Fig. 5.3. Demonstration of machine for interculturing in sugarcane at farmer's field

a time. The equipment has high ground clearance that made it suitable to operate in the field even up to 750 mm height of the sugarcane crop. The earthing-up operation could be performed with this machine till cane formation stage in the plant. The field capacity of the equipment for earthing-up was 0.39 ha/h with field efficiency of 72% (Table 5.1). The depth of furrow achieved during furrow opening mode with this machine was 22-25 cm as compared to conventional ridger where only 10-12 cm furrow depth was achieved. The farmers were very much convinced with this machine for its multi-functional tasks in sugarcane cultivation.

Table 5.1. Performance of the machine in earthing-up in sugarcane at farmer's field

Parameter	Value
Average height of crop at earthing up (mm)	816
Furrow bottom used (No.)	3
Speed of operation (km/h)	2.3
Draft (kN)	5.2
Effective field capacity (ha/h)	0.39
Field efficiency (%)	72
Cost of operation (₹/ha)	1380
Plant damage (%)	0.9

Development of cane node planter

Tractor operated cane node planter was developed (Fig. 5.4). Cane node metering mechanism was modified. Spring loaded pusher has been provided 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 of the machine. 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 conceptualised prototype trash management machine, which is under fabrication cover two rows of sugarcane and trash in between the rows. The stubble shaving unit will operate after the trash shredding operation. The total length of the shaft of trash shredding unit is 1860 mm and at which cutting blades are mounted. The diameter of the shaft is 45 mm. The cutting unit comprises three blades and its overall dimensions are 175 mm in length and 120 mm width. Total 16 numbers of cutting units comprising of three blades and two studs for each unit have been fabricated. The fabrication of trash shredding unit along with cutting blades and other components/ spare parts, frame work and stubble shaving unit has been completed.

Inter-Institutional Collaborative Research Project onTesting 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 (Fig. 5.6). Design modifications were done to make it suitable for tropical region. It was equipped with deep furrow opener to facilitate furrow method of sugarcane planting. The designed planter consisted of deep furrow opener, sharp edged blades to cut whole cane into 350 mm long pieces as seed material, metering device for application of fertilizer and insecticide, soil covering shovels and tamping roller for pressing soil cover. It could be operated by a 30-kW power tractor. It was a mounted type equipment rigidly attached with tractor through three-point linkage. 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 (SBI), Coimbatore for conducting its field adoptability trials in tropical region. Performance trials of the planter are in progress at ICAR-SBI, Coimbatore farm (Fig. 5.7).

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

Fig. 5.7. Planting with IISR - two row deep furrow sugarcane cutter planter 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 (prunning of old roots) on either side of the stubbles and fertilizer metering device for application of fertiliser at root zone. Modified prototype of Disc RMD was fabricated in the Workshop of ICAR-Indian Institute of Sugarcane Research, Lucknow and supplied to ICAR-Sugarcane Breeding Institute, Coimbatore for conducting its field adoptability trials in tropical region (Fig. 5.8). Performance trials of the planter are in progress at ICAR-SBI farm (Fig. 5.9).

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

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

UPCAR funded project, "Centre of Excellence in Farm machinery"

Development of pedal operated paddy thresher

A prototype of pedal operated paddy thresher was designed and developed for threshing of paddy crop (Fig. 5.10). Specifications of pedal operated paddy thresher are given in Table 5.2. One person can operate the machine easily by putting all crops to be threshed in a heap near the machine. The main components of the machine includes main frame, threshing drum having pegs, operator seat, winnowing fan *etc.* The pedal operating assembly can be easily detached (if necessary) from the main frame. The machine has provision of small ground wheels to help during transportation from one place to another. Winnowing fan is also provided to help in winnowing of the paddy grain after threshing. Preliminary testing of the machines was conducted at the Institute Farm (Fig. 5.11). The initial capacity of the machine was observed during preliminary testing was 1.0 q/h.

Fig. 5.10. Pedal operated paddy thresher in stationary position without and with winnowing fan

Table 5.2. Specifications of pedal operated paddy thresher

Parameter	Value
Length x Breadth x Height, mm	1500 x 900 x 1600
Diameter of the threshing drum with and without pegs, mm	260 & 380
No. of strip on the drum & pegs/strip	6 & 12-13
Length of drum, mm	500
Height of operator's seat, mm	850
Average speed of the threshing drum, rpm	300
Power transmission to threshing drum	Chain and sprocket arrangement
Number of teeth on sprocket	22 & 18 and 48 &18

Fig. 5.11. Pedal operated paddy thresher in operation

Prototype of manual crop proctective weedicide sprayer for weed management

A new prototype of manual crop protective weedicide sprayer was fabricated. A 12 V battery and a pump was attached under the tank of 15 litre capacity that act as a reservoir for herbicide solution. The operator has to keep it on his back for operation. To avoid the chances of air drifting of chemical during spraying and to protect crop from herbicide, a protective cover made of PVC was fabricated and installed on the end of the spray rod having a flat fan nozzle. The width of the cover is 50 cm. The developed prototype was tested in sugarcane crop having 90 cm row to row spacing at the Institute farm.

Fig. 5.12. Manual crop proctective weedicide sprayer for weed management in sugarcane crop

AICRP on Farm Implements and Machinery (FIM)

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

Prototypes fabricated

Machine/Implement	Source of power	Number
Deep furrow sugarcane cutter planter	Tractor	4
Deep furrow sugarcane cutter planter with marker attachment	Tractor	4
Trench opener	Tractor	1
Deep furrow opener	Tractor	3
Disc type sugarcane management device	Tractor	1
Cane bud scooper/chipper	Manual	10
Weed cleaner	Manual	1
Paddy thresher	Manual	1
Total		25

Prototypes supplied

Name of prototype	Number	Supplied to
IISR TO customized deep furrow sugarcane cutter planter with marker attachment	2	UPCSR, Shahjahanpur
IISR manual bud chipper	2	Mr. Achal Kumar Mishra, Jagdevpur, Bheera, Lakhimpur Kheri
IISR manual bud chipper	2	*Ganna Vikas Parisad*, Aira Kheri, Lakhimpur
IISR manual bud chipper	2	Seksaria Sugar Mill, Biswan, Sitapur
IISR manual bud chipper	1	*Ganna Vikas Parisad*, Jarwal Road, Bahraich
IISR manual cane node cutter-cum-bud scooper	1	Mr. Bhanesh Mani Tripathi, Vill- Khalilpur, Chhittaura, Bahraich
Total	10	

CHAPTER 6

Diversification and Value-addition in Sugarcane

Refinement of sugarcane cleaner-cum-washer for jaggery

The sugarcane cleaner-cum-washer (SC-c-W) was fabricated and its performance was evaluated with three sets of speed of scrapping rollers as given in Table 6.1. The capacity of SC-c-W was found maximum (617 kg/h) with all scrapping rollers moving at different speed with 3-cane feeding in single pass. Movement of rollers at differential speed resulted in good rubbing and cleaning action as in case with 3rd roller set. For further increasing capacity of SC-c-W, speed of lower roller of second set of scrapping rollers was increased by replacement of sprocket of 24 teeth mounted on the shaft of lower scrapping roller of 1st set by sprocket with 32 teeth. Further, replacement of 1 h.p. motor by 2 h.p. motor gave more power to the system to accommodate more canes. Thus, the capacity of machine has also improved.

Development of a jaggery furnace with efficiency boosting device

The scale up model of efficiency boosting device for IISR two-pan furnace has been fabricated. It consists of a rectangular web made out of 40 mm square pipe with overall dimensions of 760 mm x 760 mm (Fig. 6.1). It has 33 holes of 16 mm diameter each on the upper side on which nipples (50 mm x 20 mm: L x D) have been welded. All these nipples have two holes of 17 mm diameter each 10 mm above the base for sucking in flames and hot gases. The web has three verticals and two laterals. The inlet for the incoming air is provided in the middle vertical. The device has been installed in the furnace with suitable arrangements

Fig. 6.1 (a) Scale-up model of Efficiency Boosting Device and (b) nipples

(Fig. 6.2). Two gate valves have been provided for controlling the air from the blower in EBD and waste heat recovery system integrated with the furnace system.

Fig. 6.2. Installation of EBD in IISR two-pan furnace

Table 6.1. Speed and direction of rollers in different roller sets

Roller set	Position of rollers	Direction of rollers	Speed of feed rollers (rpm)	Speed of 1st set of scrapping rollers (rpm)	Speed of 2nd set of scrapping rollers (rpm)
I	Upper	Forward	15	50	75
	Lower	Backward	15	50	75
II	Upper	Forward	15	60	90
	Lower	Backward	15	60	90
III	Upper	Forward	15	50	75
	Lower	Backward	15	60	90

Performance of furnace was evaluated with following systems by conducting water boiling test:

a. Without EBD and WHRS,

b. With EBD fully open and WHRS fully closed,

c. With EBD fully open and WHRS half open,

d. With EBD and WHRS both fully open

Comparison of all the systems in terms of temperature profile of water in main pan is shown in Fig. 6.3.

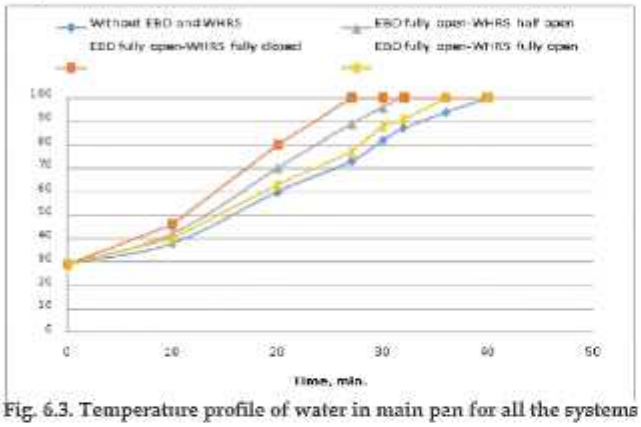


Fig. 6.3. Temperature profile of water in main pan for all the systems

The best performance of furnace was obtained With EBD valve fully open and WHRS valve fully closed due to all air moving through EBD generating more force and giving better effect (Table 6.2).

Development of IISR model jaggery unit for enhanced capacity

Design of the unit was finalized for 150 kg jaggery per batch. The unit was installed and evaluated for its performance on the basis of total consumption of bagasse, total time consumption, water evaporation rate during the jaggery preparation. The requirement of bagasse for per kg jaggery production was obtained as 2.42 kg bagasse. The analysis of the flue gas was also important to check the proper combustion of fuel inside the combustion chamber. Therefore, the flue gas contains was analyzed. During the analysis of flue gas, it was found that the amount of carbon dioxide percentage (CO_2%) which escapes from chimney was more as compared to carbon monoxide percentage (CO%) and oxygen (O_2). This indication resulted the better combustion of fuel into the combustion chamber during jaggery preparation. The total consumption of time and overall water evaporation rate of the furnace was calculated as 1.81 kg/kg bagasse, 2 h 22 minutes. The overall thermal efficiency of the furnace was 28.82% .

Comparison of test results with all the systems is summarized in Table 6.2.

Table 6.2. Comparison of results

Parameter	Systems			
	Without EBD and WHRS	EBD fully open - WHRS fully closed	EBD fully open - WHRS half closed	EBD fully open - WHRS fully open
Weight of water in main pan, kg	150	150	150	150
Weight of water in gutter pan, kg	150	150	150	150
Total water taken, kg	300	300	300	300
Time of operation, min.	120	120	120	120
Bagasse used, kg	80	80	80	80
Total water evaporated, kg	165.87	211.34	192.85	178.90
Water evaporated/kg of bagasse, kg	2.07	2.64	2.41	2.24
Bagasse used/kg of water evaporated, kg	0.48	0.38	0.42	0.45
Water evaporated/min, kg	1.38	1.76	1.60	1.49
Heat utilization efficiency, %	26.15	33.32	30.40	28.20

Development of small powder jaggery cubes

The experiment was done using the graded jaggery powder of fine (less than 0.300 mm), medium (0.500 - 0.850 mm) and large (more than 850 mm) with various levels of moisture contents. The fine (less than 0.300 mm) jaggery powder having a moisture content of 7.±0.3% was selected for the performance evaluation of the machine according to the preliminary experiment. The manually operated machine for making jaggery cubes using jaggery powder was developed. The machine was easy to operate for making jaggery cubes and helps farmers to make a marketable product using the granular jaggery powder to increase income and profit.

This machine having the dimension of 300 mm × 450 mm × 420 mm with rotating threaded handle of height 380 mm and cuboidal compartments on jaggery cube moulding frame having the dimension of 15 mm × 15 mm × 45 mm was made using the mild steel. The machine consists of various parts *i.e.* stand frame, jaggery cube frame, movable supporting plate, compression piston plate, tension rod, rotating handle, side handle. The production capacity of the machine was about 5.04 kg/hr (tested with the jaggery powder). The machine produces 0.120 kg or 20 jaggery cubes, each cube weighing 6 g in 85 seconds time frame. The mean jaggery powder loading time of 25 seconds, mean jaggery powder compaction time of 40 seconds and mean jaggery cube ejection time of 20 seconds were recorded, respectively.

The jaggery cubes were of good quality and the machine was conceived as a low-cost, easy to fabricate, easy to operate for making jaggery cubes and was useful for the domestic and small-scale industries.

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

- Purchase of equipments required for the study
- Optimization of heat treatment of sugarcane setts for microbial load reduction.
- Optimization of doses of lime juice and ginger juice.
- Kinetics of PPO activity in sugarcane juice.

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

During second year, experiments of first year were repeated but this time using whole soybean powder @ 50, 100, 150 and 200 g per 10 litre of sugarcane juice to have uniformity in quantity of soybean in powder and paste. Paste was used in same quantity like previous year with soybean to water ratio as 1:3. Therefore, absolute quantity of soybean remains the same. Jaggery samples were made following IISR jaggery making process and were analyzed for different quality parameters. More protein was found in case of soybean paste without seed coat for all the quantity of soybean and maximum value (7.03%) was obtained with 200 g soybean *i.e.* 800 g paste. Jaggery samples with soybean content as 150 and 200 g in powder or paste form (with and without seed coat) either did not set well or deteriorated within a period of one and a half month. However, samples with 50 and 100 g soybean in powder and paste form (with and without seed coat) were found acceptable. Protein content in different jaggery samples is shown in Fig. 6.4.

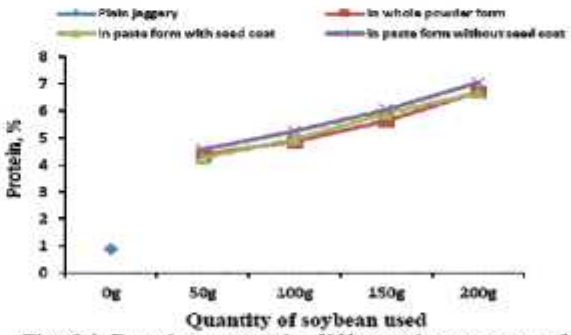


Fig. 6.4. Protcin content in different jaggery samples

CHAPTER 7

Developing Sugar Beet Varieties for Indian Agro-climates

Seed production at Sugar beet Breeding Outpost, Mukteswar

One thirty-nine sugar beet germplasm are being maintained and evaluated at Sugar beet Breeding Outpost, Mukteswar. The seeds of varieties LS 6 and IISR Comp. 1 are being produced for need based supply to the seed growers of the country. During the year under report, stecklings of 103 sugar beet entries were sent to Sugar beet Breeding Outpost, Mukteswar for seed production.

Varietal screening of sugar beet genotypes against insect pests and diseases

A total of 50 sugar beet entries were screened for insect pests and diseases. Foliar infection in all sugar beet genotypes was found. Among them, severe incidence of *Alternaria* sp and *Cercospora betae* causing leaf spot diseases were observed. Among the fifty entries, 15 entries of sugar beet were severely infected with *Alternaria* leaf spot with about 40% disease incidence. Similarly, 15 entries showed 35-40% disease incidence for *Cercospora* leaf spot. The remaining 20 entries showed mixed infection of both *Alternaria* and *Cercospora* leaf spot. The diseased specimens were cultured on artificial media (PDA) to identify the causal organism where two new *Alternaria* species *viz.*, *A. ashwinii* (MB 827099) and *A. dilkushana* (MB 827096) were identified in sugar beet. In the experiment to screen sugar beet entries against insects, among the 50 different entries, the variety SV 892 was found moderately resistant against *Spodoptera litura*.

Morphological assessment of sugar beet grown under water limiting conditions

The experiment was laid out in RBD with seven treatments and one check (LS 6) in three replications with the aim of identifying better performing sugar beet genotypes under irrigated and drought conditions. Morphological results showed that LKC 2010 and LKC 2007 had high single root weight, root length and root diameter under both the environments against check (Table 7.1).

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

The quality assessment of above mentioned seven entries against one check LS 6 was done for higher sucrose content under drought condition. The results revealed that two entries, LKC 2010 and 2007 recorded the highest sucrose content under irrigated and drought condition as compared to other sugar beet entries and the check (Table 7.2).

Table 7.1. Morphological observation on sugar beet genotypes (average of two years) under irrigated (E1) and drought (E2) condition

Variety	Single root weight (kg)		Root length (cm)		Root diameter (cm)	
	E1	E2	E1	E2	E1	E2
LKC LB	1.14	0.67	17.5	22.83	11.92	10.91
LKC 2010	1.88	0.83	25.41	22.58	12.25	11.33
LKC 2007	1.43	1.02	25.75	24.15	12.66	11.58
LKC 2006	1.11	0.57	23.91	20.41	11.92	8.83
LKC HB	1.20	0.82	19.33	17.08	10.66	6.40
IN 13	1.23	0.80	20.00	14.00	14.00	9.00
IN 4	1.20	0.50	24.00	21.00	16.00	10.00
LS 6	1.36	0.87	24.84	20.83	12.00	11.10

Table 7.2. Juice quality of sugar beet genotypes (average of two years) under irrigated (E1) and drought (E2) condition

Variety	Sucrose (%)		Brix		Purity (%)	
	E1	E2	E1	E2	E1	E2
LKC LB	17.33	15.74	18.53	19.28	93.10	92.58
LKC 2010	20.84	17.44	22.93	21.16	91.66	75.66
LKC 2007	19.75	17.11	22.21	20.91	90.98	78.57
LKC 2006	16.26	15.57	18.98	18.46	83.25	99.80
LKC HB	17.63	16.70	20.63	20.70	85.71	83.50
IN 13	20.00	20.00	24.00	22.10	83.33	90.33
IN 4	18.00	16.00	20.70	22.60	86.99	70.80
LS 6	17.60	19.00	20.63	19.95	85.33	73.29

CHAPTER 8

Statistics, Economics and ICT

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

There were fluctuations in sugarcane production and its supply to sugar mills during past five years. It affected economic feasibility, profitability and sugarcane price arrears on sugar mills. The integrated sugar-energy complex having 7,000 TCD capacity in U.P has comparative advantage in comparison to similar capacity sugar-energy complex in Maharashtra. Keeping in view, sugar production scenario, sugarcane processing should be diversified as per market product demand with new innovative products such as specialty sugar for various cliental to focus higher revenue realization to achieve economic viability and sustainability. There is need to establish agro-processing hubs for other commodities processing and its marketing throughout year by using the sugar mills infrastructure.

There were fluctuations in sugarcane production and productivity; sugar recovery stagnation due to climatic conditions such as drought and water scarcity in Maharashtra during past few years.The adoption of early maturing high sugar varieties, water saving, mechanization of interculturing operations, ratoon management, autumn area surge and inter-cropping with short durational pulses, oilseeds and vegetables have improved the farmers income in U.P. The area under EMV cane varieties has increased from 19 per cent to 88 per cent during past five years. The farmers have adopted integrated nutrient and pest management strategies, mechanized trench, wider row spacing and water saving techniques to enhance productivity to minimize cost and enhance profitability. The use of mechanical power in sugarcane cultivation has upward trends in Maharashtra and Uttar Pradesh have improved over the years to address issues of labour scarcity and higher wages. They adopted sugarcane cutter planter/mechanized trencher for crop planting, multi-purpose power tillers and rotavator for mechanical intercultural operations to reduce expenses. The research findings conclude that the intercrops inclusion in sugarcane based cropping systems increase profitability, enrich soil health, adds income and labour employment, food and nutritional security.

Economics of sugar production in Uttar Pradesh and Maharashtra

The comparative sugar processing cost in two major sugar producing states was estimated and presented in Table 8.1. It revealed that the cost of sugar production varied from ₹ 3,447 to ₹ 3,581/quintal in standalone sugar mills with crushing capacity less than 4,000 TCD in U.P. and Maharashtra, respectively. The integrated sugar-energy complexes of 7,000 TCD or more have sugar production cost ₹ 3,342 to ₹ 3,582 per quintal. The cost of sugarcane has a lion's share of 74 to 82% in total cost of sugar production in different capacity integrated sugar complexes/mills.

Table 8.1. Economics of sugar production in Uttar Pradesh and Maharashtra during 2019-20

(in ₹/quintal sugar)

Sl. No.	Parameters/ Cost Components	Stand alone < 4,000 TCD		Sugar + Co-Gen 4,000-7,000 TCD		Sugar+ Distillery+ Co Gen >7,000TCD	
		UP	MS	UP	MS	UP	MS
1	Sugarcane cost including harvesting and transport	2872	2828	2681	2516	2670	2790
2	Total cash conversion cost	383	567	360	625	395	577
3	Total interest & depreciation	193	186	198	309	277	215
4	Total conversion cost	575	753	558	935	672	792
5	**Cost of sugar production**	3447	3581	3239	3451	3342	3582

Pravaranagar Sugar Mill has in house ethanol distilleries, has diverted B-heavy molasses for bio-ethanol production. The sugar recovery of DCM (Sugar) units was lower as compared to previous sugar season as these units have diverted B-heavy molasses for ethanol and hand sanitizer manufacturing during year 2019-20. The sugar-energy complexes in UP adopted efficient processing and distillery technologies in recently installed distillation plants at Ajbapur (U.P). The cooperative sector mills have to increase their crushing capacity, sugar recovery to make them financially viable, self-reliance and competitive with private sector mills in U.P. and Maharashtra.

Economics of bio-ethanol production

As per Ethanol Blending Programme (EBP) policy 2018, Government has fixed 10 and 20 per cent bio-ethanol blending targets with petrol by year 2022 and 2025, respectively. In the wake of higher domestic prices, low exports and high stocks of sugar, Govt. of India has permitted integrated sugar-energy complexes having distilleries for utilization of B-heavy molasses and sugarcane juice for bio-ethanol production. The economics of bio-ethanal from different routes in sugar mills.Table 8.2 revealed that the bioethanol produced through B-heavy molasses gave net income of ₹ 19.37 per litre to the distillery as compared to ₹ 12.02 per litre by conventional final molasses route. The market sugar prices ₹ 7,000 per tonne, declared by the Government of India as MSP for sugar was applied to estimate economics of bioethanol production in integrated sugar-energy complexes having 7,000 TCD capacity. The sugarcane fair remunerative price (FRP) ₹ 2,850 per tonne on base recovery of 10% declared by CACP for sugar season 2020-21 has been applied to workout returns and profit from bioethanol production directly from sugarcane juice. The bioethanol produced directly from sugarcane juice gives net income of ₹ 7.44 per litre The findings conclude that the diversion of B-heavy molasses may be probable option for improving sugar mills economic health and enhance bioethanol supply to achieve 10% EBP targets by year 2022.

The diversion of BH molasses for ethanol production reduce steam consumption in sugar processing which led to bagasse saving, improve sugar colour and quality; increase power supply to national grid through cogeneration. It may contribute packaging cost saving, reduces sugar opening stock, transport cost and curtail per unit effluent treatment cost in sugar-energy complex.

To improve financial viability of sugar-energy

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

Particulars/ Economic parameters	Final C-molasses	B-H molasses	Sugarcane juice
Sugar mill crushing capacity (TCD)	6500	6500	6500
Sugar recovery (%)	12.2	10.85	0
Molasses production (in % cane crushed)	4.5	6.5	0
Sugar production (tonnes/day)	793	705.25	0
Molasses production (tonnes/day)	292.5	422.5	0
Sugar price (₹/tonne)	32000	32000	32000
Sugarcane/molasses price (₹/tonne)	5100	9000	2850
Bio-ethanol price (₹/litre)	45.69	57.61	62.65
Sugar production losses (tonnes)	0	87.75	0
Sugar revenue losses (In ₹ lakh)	0	28.08	0
Cost of cane/ C molasses (In ₹ lakh)	14.92	13.16	185.25
B-heavymolasses price(In ₹ lakh)	0	38.03	0
Bio-ethanol recovery(Litre/tonne)	230	365	70
Bio-ethanol production(Litre/day)	67275	154213	455000
Revenue from ethanol(₹ lakh/day)	30.74	88.84	285.06
Raw material cost (₹/litre)	22.17	26.74	40.71
Conversion cost (₹/litre)	11.50	11.50	14.5
Cost of bio-ethanol production (₹/litre)	33.67	38.24	55.21
Net profit (₹/litre)	12.02	19.37	7.44

processing sector the Govt. of India had reduced the GST on ethanol from 18% to 5% and declared premium and differential price policy to encourage product diversification for sustainable growth of Indian sugar mills. Out of total supply, 77% of bioethanol made from sugarcane juice/B-heavy molasses. India has achieved the EBP blending of 8.36%.

International sugar trade and export opportunities for Indian sweeteners

The acceptability of India as a reliable exporter has improved during past decades. It provides an opportunity to the Indian raw sugar and traditional sweeteners as an alternate to export surplus sugar and jaggery based products to international markets.

The Govt. of India has encouraged sugar export through reduction in export tax and logistic support. The sugar export has improved as prices in global market are firm.

The Government has made obligatory Minimum Indicative Export Quota (MIEQ) for sugar export promotion. To support the sugar export, it allowed the swap between MIEQ and domestic sales quota for year 2019-20. It has received encouraging response from sugar mills. It has reallocated nearly 1.0 lakh tonne sugar as per mills export performance and contracts signed by them. The sugar export contracts of 5.5 million tonnes (90% of MIEQ limit) have been finalized.

Impact of IISR technologies in sustaining sugarcane production in India

A study on impact assessment of Institute developed technologies such as sugarcane cutter planter, varieties developed and other production and protection technologies was carried out. The returns to research due to sugarcane cutter planter research were estimated at ₹ 35.1 per ₹ invested. Institute developed variety CoLk 94184 has become popular in Central & eastern UP and Bihar and which has been grown in about 2 lakh ha area. The benefits in monetary terms due to this variety worth ₹ 411 Crores, out of which 80.9% was increase in farm income due to higher price increase on account of its being an early variety was, and 19.1% was income to the sugar mills on account of higher sugar recovery.

Assessment of bio-control of sugarcane insect particularly woolly aphid was attempted. The information on the nature and extent of insect infestation was compiled. The perusal of the literature revealed that severe infestation of sugarcane woolly aphid was reported in 2002 in Maharashtra and Karnataka, and its incidence remained in the fields up to 2005-06. About 3.2 lakh ha sugarcane area has been reported as affected due to this insect. It was found that about 19% area in Karnataka and 29.34% area in Maharashtra were affected on account of this insect infestation. The average reduction in sugar recovery in sugar mills was 27% and yield loss was up to 23%, even if plant protection chemicals were used. However, integrated use of chemical and biological control became more effective as it was followed by 29% farmers. The loss was reduced to 10.5% under integrated use of biological and chemical control. There was net saving of 12.5% in yield when bio-control measures are used in combination with the chemical control measures. In infested sugarcane area in Maharashtra and Karnataka, economic saving by using integrated control measures for woolly aphid was worked out at ₹ 1,056 crores (range ₹ 960 to ₹ 1,152 crores) per year for sugarcane with average cane yield of 80 t/ha.

Development of district-level database on sugarcane growth and sustainability

Data on sugarcane area, production and productivity was compiled for the last 30 years in respect of major sugarcane growing areas. The sugarcane growth scenario was analyzed at national, regional (sub-tropical and tropical regions) and all major cane growing states for the period of 30 years from 1989-90 to 2018-19. The analysis at district level has also been carried out for Uttar Pradesh. The analysis at national and regional level revealed that the area growth in sugarcane was more than 1 per cent per year at all-India level as well as for the tropical region while it was less than 1 per cent per year in sub-tropical region (Table 8.3). The productivity growth, though less than 1 per cent per year, it was high in sub-tropical region compared to all-India level as well as tropical region. The productivity growth in tropical region was negative highlighting that yield levels in last 10 to 20 years could not increase beyond already achieved level. The 30-year period was also sub-divided to analyse the growth scenario for every decade. During the period 2009-10 to 2018-19, the productivity growth in sub-tropical region was quite impressive at 3.499% CAGR and the area growth was also more than 1 per cent per year. The growth was negative in tropical region during same period for sugarcane area and productivity levels. The analysis highlights that there is potential to increase the productivity levels in sub-tropical region and this region must be given emphasis for future sugarcane crop planning.

In sub-tropical region, Punjab, Haryana and Bihar has experienced significant area growth of 3.5 per cent and more while Uttar Pradesh, already a sugarcane

intensive state, has shown growth of less than 1 per cent per year during the last deerde (Table 8.4). The productivity growth was quite impressive in U. P., Bihar and Punjab. The productivity growth in Haryana and Uttarakhand was comparatively low, but were positive as 1.44% and 1.85%, respectively.

In tropical region, the area and productivity growth has remained negative for Tamil Nadu and Gujarat. The area growth was also negative with marginal increase in productivity in Andhra Pradesh. It highlights that these states are finding it difficult to maintain sugarcane area and productivity levels already achieved. The major sugarcane growing states like Maharashtra and Karnataka has experienced positive area growth of 0.774% and 1.214%. These states also could not maintain the achieved productivity levels and exhibited negative productivity growth during past deade.

District-level sugarcane growth scenario in UP

The district-wise information on sugarcane area, production and productivity in UP was compiled and analysed for the period 2008-09 to 2017-18. Strategic distribution of the sugarcane growing districts in the state was worked out. Out of 118 districts in India, where sugarcane has more than 5,000 ha area and its cultivation directly supports the sugar industry, 41 districts were in UP State. Sugarcane growth scenario was analysed for these districts of UP. The CAGR of area and productivity of sugarcane in these districts as well as their relative spread index (RSI) and relative yield index (RYI) was worked out. Out of 41 major cane growing districts almost all the districts (except two districts) outside sugar industry zones have experienced positive growth in productivity during the period. However, 13 districts including the most intensive districts of Meerut and Muzaffarnagar have exhibited negative growth in area. The districts were classified on the basis of growth scenario as given in Table 8.5.

The analysis reveals that the most of districts in state have negative or no growth in terms of sugarcane area districts of Pilibhit, Bareilly, Sitapur, Lakhimpur Kheri, Bahraich, Gonda, Hardoi, Shravasti, Kasganj and Ghazipur have exhibited significant and positive growth in area as well as in productivity during the last decade. These districts have the potential for future growth and may be considered as high potential districts. They also need to receive R & D input for ensuring sustainable growth of sugar sector. The analysis further highlights that central UP has emerged as the major region responsible for growth of sugar sector in U.P. while western UP has finding it difficult to maintain its sugarcane intensiveness as shown by negative area growth.

Estimation of sugarcane cost of cultivation in UP for season 2020-21

Based on rapid appraisal of 14 farmers in Central UP

Table 8.3. Area and productivity growth (CAGR-%) of sugarcane at regional level in India

Period	Sub-tropical		Tropical region		All India	
	Area	Productivity	Area	Productivity	Area	Productivity
1989-90 to 1998-99 (P1)	1.003	1.162	2.917	0.399	1.782	0.972
1999-00 to 2008-09 (P2)	0.867	-0.054	1.602	-0.556	1.218	-0.276
2009-10 to 2018-19 (P3)	1.004	3.499	-0.121	-0.731	0.518	1.272
Whole Period (P)	0.838	0.649	1.662	¯0.067	1.191	0.363

Table 8.4. Area and productivity growth (CAGR%) of sugarcane during P3 (2009-10 to 2018-19) at state level

Indicator	Sub-tropical States				
	Uttar Pradesh	Bihar	Uttarakhand	Haryana	Punjab
Area	0.795	3.674	-1.697	3.435	4.410
Productivity	3.657	4.879	1.858	1.442	3.516
Indicator	**Tropical States**				
	Maharashtra	Karnataka	Tamil Nadu	Andhra Pradesh	Gujarat
Area	0.774	1.214	-7.466	-6.766	-0.792
Productivity	-0.257	-1.283	-0.931	0.160	-1.971

(Hardoi and Sitapur districts), cost of cultivation for the sugarcane season 2020-21 in UP was worked out. The per tonne cost of sugarcane production were communicated to the Sugarcane Department, Government of Uttar Pradesh as an advisory note for fixation of sugarcane price (SAP) in UP. The cost of cultivation of sugarcane was ₹ 2,984 per tonne.

Analysis of agricultural labour absorption in sugarcane cultivation in major cane growing states of India

The pattern and trend in labour use in sugarcane cultivation in India and at disintegrated level, across farm sizes in intensive agro-climatic zones of two major sugarcane growing states, Maharashtra and Uttar Pradesh was analysed for the period 2000 to 2017.

The labour use per sugarcane crop was high in tropical compared to sub-tropical. The U.P. used 1191.4 hrs per ha while Maharashtra used 1728.8 hrs per ha during QE year 2016-17. The decrease in labour use sugarcane during the reference period was found to the extent of 16% in Maharashtra and just 1.6% in U.P..

Analysis of agro-climatic zones (ACZs) in U.P. reveals that Central Plain Zone (CPZ) has exhibited an increase (50.7%) in total human labour, casual labour (CL), machine labour (ML) and bullock labour (BL) absorption while the main sugarcane intensive zone in western UP (WPZ) has observed a decline in absorption in previously achieved levels. In Maharashtra, main sugarcane intensive zone, Transition Zone -2 (TRZ2), has observed an increase in the HL, CL, AL, ML and BL use, while the most of other zones have recorded a decrease in these components. Analysis across farm sizes reveals that total HL and CL use has increased on medium farms in UP and on large farms in Maharashtra. On the contrary, ML use has increased on marginal farms in UP while it has increased on marginal as well as on large farms in Maharashtra.

The labour productivity in sugarcane at national level has increased by 28.1%. The factor shares (share of wage in value of output) increased insignificantly from 4.5% to 4.7% at all India level, depicting that labour productivity increased largely due to mechanization resulting in displacement of labour, rather than due to technological changes.

There is a need to promote mechanization to mitigate labour scarcity and ensure high labour productivity.

Development of web-based reporting system for AICRP on Sugarcane

A web-based application, AICRP Reporter, has

Table 8.5. Classification of sugarcane growing districts in UP on the basis of growth criteria

Sl.	Growth Criteria	Districts
	Highly intensive sugarcane districts (RSI >=100)	
1	RYI>100, Productivity growth +ve and Area growth +ve	Pilibhit, Bareilly, Lakhimpur Kheri
2	RYI>100, Productivity growth +ve and Area growth constant	Hapur, Bagpat and Amroha
3	RYI>100, Productivity growth +ve and Area growth -ve	Shamli, Meerut, Bijnore, Ghaziabad, Muzaffarnagar and Bulandshahar
4	RYI 50 -100, Productivity growth +ve and Area growth +ve	Gonda and Sitapur
5	RYI 50 -100, Productivity growth +ve and Area growth constant	Kushinagar, Saharanpur, Sambhal and Basti
6	RYI 50 -100, Productivity growth +ve and Area growth -ve	Balrampur and Moradabad
	Moderately intensive sugarcane districts (RSI 50 to <100)	
7	RYI 50 -100, Productivity growth +ve and Area growth +ve	Shahjahanpur, Hardoi, Bahraich and Shravasti
8	RYI 50 -100, Productivity growth +ve and Area growth constant	Rampur, Ayodhya, Maharajganj and Badaun
	Less intensive sugarcane districts (RSI <50)	
9	RYI 50 -100, Productivity growth +ve and Area growth +ve	Kasganj and Ghazipur
10	RYI 50 -100, Productivity growth +ve and Area growth constant	Sultanpur and Ambedkarnagar
11	RYI 50 -100, Productivity growth +ve and Area growth -ve	Aligarh, Ballia, Mau, Deoria, Jaunpur, Barabanki and Azamgarh

Note: RSI and RYI refers to relative spread index and relative yield index

been developed to provide an effective data recording and reporting platform for AICRP on Sugarcane. User can access the software over the Internet using URL https://iisr.icar.gov.in/iisr/aicrp/software/index.jsp from any standard web browser. During the year 2020-21, modules for recording updation and deletion of experimental trial data of crop production experiments have been developed.

In addition, modules for recording and updation of daily and monthly meteorological data of AICRP centres and the modules for analysis of experiments under Split Plot Design were developed.

The Added Treatment Profiles Treatment and Attribute Schedule in the system for ZVT and Crop Production trials of year 2020-21 was added as per technical programme.

Excel files for recording of ZVT data were created. Links of same are accessible to AICRP Centre Incharge's, Principal Investigators and Project Coordinator after sign-in on AICRP Reporter software. Modules to manage stakeholders remarks in AICRP trials were also updated.

AICRP (Sugarcane) collected data of for year 2019-20 from its centres through this software using both online data recording and through excel file generation. The architecture of AICRP Reporter is given in Fig. 8.1.

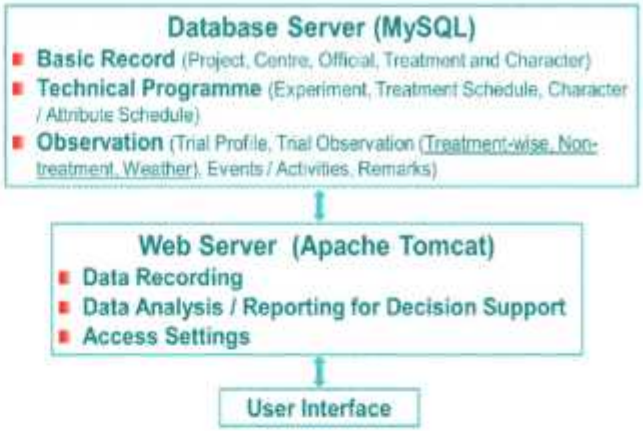
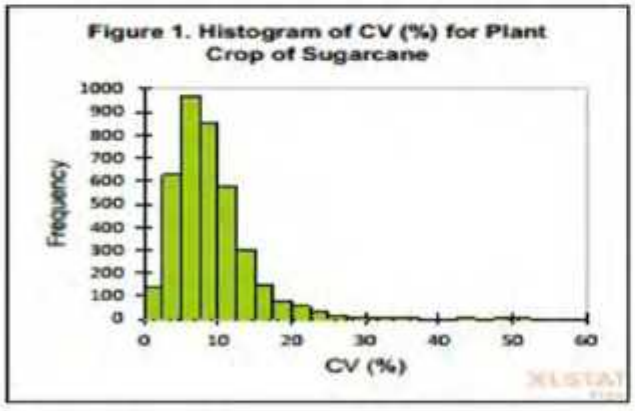


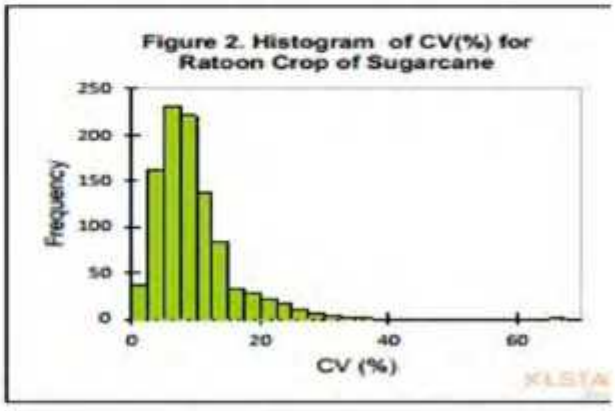
Fig 8.1. Architecture of AICRP Reporter

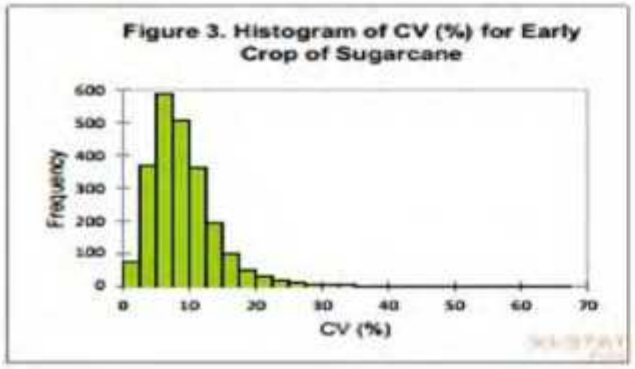
Online database and mixed model analysis of sugarcane varieties tested/released in India

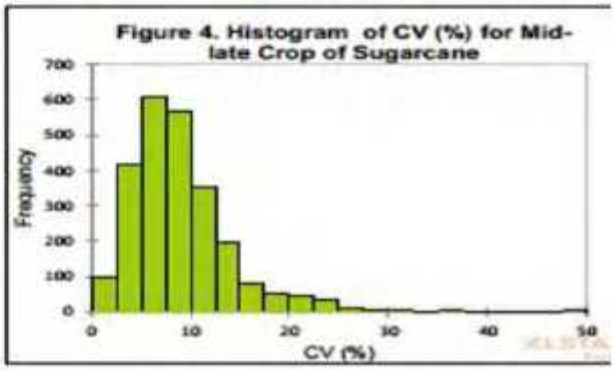
Upper limit of coefficient of variation for cane yield in field experiments

During 1991 to 2020, a large number sugarcane experiments (5265) were conducted in five sugarcane zones. The trials were conducted in Randomized Complete Block Design (RCBD). Number of replications were three for nearly 98% of the experiments. The study aims to know the extent of variability in experiments in different zones. The data on standard error, coefficient of variation (CV) and critical difference (CD) of each experiment were collected for yield and sucrose (%).









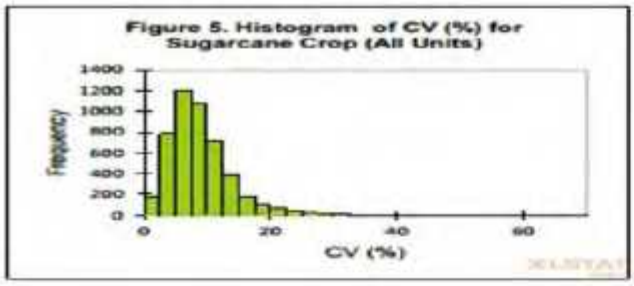


Table 8.6. Bootstrap statistic and upper fiducial limit of CV (%) for sugarcane crop (All units)

	ALL units		
N	4803	4803	4803
Level	10	5	1
Statistic	8.92	8.92	8.92
Bias	-0.000607	-0.000824	-0.000002
Std. Error	0.074	0.074	0.074
Lower limit	8.796	8.776	8.734
Upper limit	9.037	9.061	9.110
Z test	120.286*	119.949*	120.941*
Interval	0.242	0.285	0.376

*Significant at 5% level of significant

Out of 5265 experiments, significant results were found in 91.23% experiments for cane yield. The majority of experiments had CV below 15%. and the distribution was non-normal. The CV (%) substantial departure from normaly (Fig. 8.2 A,B,C,D). A nonparametric Bootstrap method was used to calculate the upper limit of CV(%), when normality assumption was not required.

Bootstrap bias is negligible for all the crop of sugarcane. As level of significance increases, the upper limit of CV (%) decreases. It is inferred that upper limit of CV (%) is more in ratoon than the plant crop because the gaps in sugarcane field is more in comparison to plant crop. In case overall experiments, upper fiducial limit of CV (%) for sugarcane was estimated as 9.110, 9.061 and 9.037 at 1%, 5% and 10% level of significance, respectively (Table 8.6).

Efficiency of designs in field experiments

Two experiments were conducted in to randomized complete block experiment replicated twice with 21 cultivars and alpha lattice design with incomplete blocks with two replications, 21 cultivars, 3 blocks within a replicate and 7 plots per block in each replication. The randomization of 21 cultivars was done with Design Resources software. The data for Germination (30 days after planting) and Germination (60 days after planting). Lay out plan, randomization and statistical analyses of alpha lattice design and randomized complete block design were carried out by using SAS 9.3.

Efficiency of Alpha Lattice Designs (ALD) as compared to Randomized Complete Block Design (RCBD) was worked out. An estimated relative efficiency (ERE) less than 1 indicates that RCBD is more efficient, while value nearly equal to 1 suggests that the two designs yield similar results. Value of ERE greater than 1 suggests that alpha lattice design is more efficient design than RCBD.

Coefficient of variation (%), error mean square and standard error of the difference between two means, efficiency of designs, gain in efficiency and least square mean of different varieties for two designs were calculated. Significance at 5% level of different characters in different designs were tested.

Coefficient of variation (%) for most of the characters in Alpha Lattice Design was found low in comparison to Randomized Complete Block Design. indicating that Alpha Lattice Design is more suitable. It indicates more precise estimate of standard error of mean. In this analyses, coefficient of variation is either less than in Alpha Lattice Design in comparison to Randomized Complete Block Design or it is equal in both the designs.

Efficiency of Alpha Lattice as compared to RCBD

Relative efficiency of Alpha Lattice as compared to RCBD in field were better for germination (30 days), germination (60 days), tiller (90 days), tiller (180 days), tiller (210 days), sucrose (%) at 10 months, height at harvest, girth at harvest, internode at harvest, total weight at harvest. Similarly gain in efficiency (%) of Alpha Lattice Design (Field) *vs* RBD in Alpha Lattice Design (I) were found more.

Alpha Lattice Design was found superior over both the Randomized Complete Block Design. However in qualitative characters, Alpha Lattice Design was inferior than Randomized Complete Block Design because qualitative characters in sugarcane mainly depend upon weather factors like low temperature. Overall, Alpha Lattice Design was found superior over Randomized Complete Block Design for detecting genotypic difference of mean in advance level of trials of sugarcane specially conducted under Varietal Improvement Programme of AICRP on Sugarcane.

Least square mean of different varieties conducted in Alpha Lattice Design and RCBD for ranking of the varieties are presented in Table 8.8. Out

Table 8.7. Relative efficiency of Alpha Lattice as compared to RCBD and gain in efficiency

Sugarcane Character	Alpha Lattice Design (Field) *vs* RBD in Alpha Lattice Design (I)	Alpha Lattice Design (Field) *vs* RBD in Field (II)	Gain in efficiency of I	Gain in efficiency of II
Germination (30 days)	199.10	112.07	99.10	12.07
Germination (60 days)	198.09	152.30	98.09	52.30
Tiller (90 days)	123.25	126.98	23.25	26.98
Tiller (180 days)	127.47	305.27	27.47	205.27
Tiller (210 days)	91.95	112.27	-8.05	12.27
Brix (%) at 10 months	99.44	64.37	-0.56	-35.63
Sucrose (%) at 10 months	101.53	97.01	1.53	-2.99
Height at harvest	113.48	151.03	13.48	51.03
Girth at harvest	121.80	12.71	21.80	-87.29
Brix at harvest	90.96	26.75	-9.04	-73.25
Sucrose at harvest	92.35	19.63	-7.65	-80.37
Internode at harvest	118.43	54.80	18.43	-45.20
Total cane at harvest	93.48	104.27	-6.52	4.27
Total weight at harvest	100.43	160.54	0.43	60.54

Table 8.8. Least square mean of different varieties conducted in Alpha Lattice Design and RCBD

Variety	Tiller (90 days) in Alpha Lattice Design	Tiller (90 days) in RCBD	Tiller (180 days) in Alpha Lattice Design	Tiller (180 days) in RCBD	Yield in Alpha Lattice Design	Yield in RCBD
Co 0238*	**53.65**	**62.26**	**75.69**	**68.92**	**32.17**	**33.49**
CoJ 64*	**51.13**	**51.62**	**50.23**	**56.50**	**15.77**	**12.11**
CoLk 9202	**82.25**	**73.14**	**87.96**	**88.44**	75.14	77.47
CoPk 05191	**90.44**	**94.67**	**96.98**	**96.62**	**55.92**	**59.65**
CoLk 15205	97.93	85.18	86.34	92.84	56.26	48.07
CoLk 09709	33.83	42.36	47.22	41.07	36.74	41.20
CoLk 94184*	83.27	87.49	100.92	100.56	62.25	65.97
CoSe 03234	86.36	73.61	106.01	112.52	79.33	71.14
CoS 08276	64.15	72.68	59.95	53.80	45.38	49.85
CoPant 5224	110.17	101.15	68.28	68.15	46.80	45.99
Co 05011*	105.30	110.18	99.30	99.17	79.36	73.30
CoS 08279	71.78	75.92	105.32	105.57	50.77	57.64
CoSe 01434	117.75	121.98	105.78	105.42	65.56	69.29
CoPant 97222*	79.88	67.12	75.23	81.73	65.21	57.02
CoS 97261	70.86	79.39	97.68	91.53	62.36	66.82
CoS 767*	85.40	76.38	106.24	106.11	57.68	56.87
Co 1148	93.03	97.91	111.33	111.21	64.93	58.87
BO 91*	102.80	106.94	100.92	101.18	33.18	40.05
CoLk 09204	116.65	107.63	114.34	114.21	78.28	77.47
CoLk 11206	146.04	150.91	90.27	90.14	50.66	44.60
CoLk 14201	72.24	76.38	92.82	93.07	71.91	78.78

*- are checks or standard in Advance Varietal Trials and Initial Varietals Trials of North West Zone and North Central Zone of All India Coordinated Research Project on Sugarcane.

Figures marked by red colour depicts top four rank varieties.

of twenty-one varieties, among top four varsities, three are same in Alpha Lattice Design and RCBD for tillers at 90 and 180 days and yield. It indicated that ranking of the varieties are not different for cane yield, if we change the design. Most of the varieties are superior than the tested varieties. Seventy five per cent ranks of the varieties are same in both the design.

Effect of blocking in Alpha Lattice Design and RCBD

In Alpha Lattice Design, out of fourteen characters, only two qualitative characters *i.e.* Brix and sucrose at 10 months were found significant at 5%. Fourteen characters were tested non-significant at 5% level of significance for replications which also indicated that the blocks formed in RCBD were homogeneous within replication. If we compare level of significance (value of alpha) in Alpha Lattice Design and RCBD in field, it was found less for Alpha Lattice Design than RCBD. So we can conclude that the blocks in Alpha Lattice Design were more homogeneous than RCBD.

It is concluded that alpha lattice design was more efficient than complete randomized block design conducted separately with same number of varieties for most of biometrical characters.

CHAPTER 9

All India Coordinated Research Project on Sugarcane

In order to enhance sugarcane and sugar productivity in different sugarcane growing zones, relevant programmes were undertaken which encompass crop improvement for developing high yielding and high sugar varieties, crop production and crop protection technologies to enhance cane productivity, sugar recovery and to sustain soil fertility. The approved research programmes were conducted at 22 regular and 14 voluntary centres. The salient achievements of the project were also presented and discussed 33rd Biennial Workshop of AICRP on Sugarcane held at the ICAR-IISR, Lucknow during October 18-19, 2020. The salient achievements in terms of varietal/technological development are mentioned below:

A. Varietal development programme

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 various centers for both drought as well as water-logging conditions. A total of 26 Zonal Varietal Trials (12 in early, 10 in mid-late and 4 trials combining early and mid-late maturity groups) were conducted during the year 2019-20. A total of 47 entries in early group, 52 entries in mid-late group and 47 entries combining both the maturity groups were evaluated. Among the entries evaluated, 19 entries each in early and mid-late and 6 entries in the combined trial of early and mid-late groups were found to be promising. In Peninsular Zone, MS 13081 and Co 13013 were identified as the qualifying entries based on the mean performance in two plant and one ratoon crop.

Sugarcane varieties identified

Following four sugarcane varieties have been identified in Varietal Identification Committee Meeting of AICRP on Sugarcane :

CoS 12232 (Sahaj 3) : This sugarcane variety has been developed by UPCSR, Shahjahanpur in mid-late group

for the North West Zone and identified in 2019. The variety has exhibited cane yield 88.86 t/ha, CCS yield 11.21 t/ha and sucrose 18.18% in juice. This variety is non lodging, non flowering, better ratooning and nutrient responsive. Reaction to red rot was R to MR.

Co 13035 (Karan 14) : This sugarcane variety has been developed by ICAR-SBI Regional Centre, Karnal in

mid-late group for North West Zone and identified in 2019. The variety has exhibited cane yield 86.76 t/ha, CCS yield 11.00 t/ha and sucrose 18.25% in juice. Reaction to red rot was R to MR. The variety is least susceptible to shoot borer, top borer and stalk borer.

CoC 13339: This sugarcane variety has been developed by SRS, Cuddalore in mid-late group for East Coast Zone and identified in 2019. The variety has exhibited cane yield 117.97 t/ha, CCS yield 15.16 t/ha and sucrose 18.21% in juice. This variety is moderately resistant to red rot and YLD.

Co 12009 (Sankalp) : This sugarcane variety has been developed by ICAR-SBI, Coimbatore in mid-late

group for Peninsular Zone and identified in 2019. The variety has exhibited cane yield 119.65 t/ha, CCS yield 17.31 t/ha and sucrose 19.91% in juice. Reaction to red rot, MS-MR (plug) and R (nodal), resistant to smut & YLD.

B. Crop production and protection technologies

To address the abiotic stress conditions and emerging location specific issues, the studies under crop production discipline were mainly concentrated under the aspects such as - integrated nutrient management schedule, for sugarcane production system to ensure good soil health and crop productivity; agronomic evaluation of promising genotypes for their performance potential under variable row spacing and enhanced fertility level, assessment of climate change impact on sugarcane productivity and also to assess the water productivity and drought tolerance potential of newly released varieties of sugarcane for different agro climatic conditions. The results are summarized as below:

- The combined application of organic and inorganic sources of nutrients was found conspicuously better over the use of fertilizers alone across the centers. Application of nutrients through organic sources in plant-ratoon system brought about substantial enhancement of soil health parameters in most of the sugarcane growing zones.
- Addition of 20 t/ha FYM/compost along with inorganic fertilizers applied on the basis of soil test, soil test crop response for targeted yield or on the basis of general recommendation for the region has shown positive effect on sugarcane growth and yield in second ratoon crop.
- Response of bio-fertilizers (*Azotobacter/ Gluconacetobacter/ Azospirillum*/PSB) was more pronounced in peninsular zone. Comparative response of FYM/Compost @ 10 t/ha with biofertilizers (*Azotobacter/Gluconacetobacter* +PSB) and soil test basis application of NPK on number of millable cane were found more prominent in the North Central and East Coast Zone.
- Elite genotypes belonging to early and mid-late maturity groups were found to perform well at wider spacing of 120 cm in sub-tropical region and at 150 cm in Peninsular and East-Coast Zones.
- Moisture stress during pre-monsoon growth phase brought about significant reduction (20 to 35%) in cane yield across all the zones. Keeping this in view, water efficient sugarcane varieties both early and mid-late have been identified for different zones.

The crop protection included the studies on the aspects both of Plant Pathology and Entomology. In Plant Pathology, more number of isolates were obtained from the popular varieties such as Co 0238, Co 89003, CoJ 64, CoJ 85, CoS 8436 and CoM 0265. In North West Zone, the centres *viz.*, Lucknow and Shahjahanpur reported emergence of new strain of *C. falcatum*, causing disease incidence in the variety Co 0238, while Karnal centre reported possible emergence of new pathotype *Cf* 89003 (isolated from variety Co 89003). Sixteen centres carried out survey for occurrence of sugarcane diseases that are naturally occurring in their locations.

- In Uttar Pradesh, red rot was noticed to the tune of 7 to 60% in Co 0238 and up to 30% in CoSe 95422 and CoS 8436. Karnal centre reported incidence of

red rot in the varieties CoJ 88 (20-30%) and CoH 167 (20.0%).

- In North Central Zone, Pusa centre observed 10% incidence of red rot and smut and up to 20% wilt incidence in many varieties. In East Coast Zone, Anakapalle recorded red rot incidence in Co 62175 and CoV 89101. The centre also recorded PB upto 30% and wilt upto 20%.
- In Peninsular Zone, Navsari centre reported major diseases like Wilt, Red rot, Smut *etc.* Coimbatore centre reported that YLD and grassy shoot disease (GSD) were more common across the varieties.
- However, wilt was observed in new variety Co 0212 and Red rot in Co 86027. The centre also reported severe incidence of Pokka boeng in Co 06022 and PI 1110. Five centres were involved in pokkah boeng management experiment and the results showed that sett treatment (over night soaking) along with foliar spray of fungicide (Carbendazim @ 0.1%) at 15 days interval was found most effective.
- During the year 2019-20, six projects were conducted in entomology discipline of AICRP (S) at 10 centres (regular and voluntary) under four sugarcane growing zones of India. Severe to moderate incidence of sugarcane insect pests *viz.*, ESB, root borer, internode borer, top borer, white grub, scale insect, white fly, mealy bug, web mite, sugarcane woolly aphid, rusty plum aphid, thrips, black bug were reported from different parts of the country.
- Some uncommon insect pests *viz.*, plant hopper (*Eoeurysa flavocapitata*), blister mite were also reported. Invasive insect pest, Fall army worm (*Spodoptera frugiperda*) was reported this year also on sugarcane from Andhra Pradesh and Tamil Nadu.
- Mass multiplication of sugarcane bio-agents using cost effective techniques was done for *Trichogramma chilonis, Eumicrosoma sp., Fulgoraecia melanoleuca, Beauveria brongniartii, B. bassiana and Metarhizium anisopliae* for use against various insect pests.
- Low incidence of insect pests with higher yield and B:C ratio was recorded in IPM plots as compared to farmers' practice in all the experiments conducted by different centres.

CHAPTER 10

Outreach Programmes & Technology Management

Entrepreneurship development for sugarcane seed production and multiplication

Seed cane of varieties *viz.*, CoLk 94184, CoLk 09204, Co98014, Co 0118, Co 08272, Co 08279, CoLk 11206, CoLk 11203, CoLk 14201, CoS 13235, Co 15023 and CoS 09232 was sown on farmers' fields in Sitapur, Lakhimpur Kheri, Farrukhabad, Ballia, Pilibhit and Hardoi districts of Uttar Pradesh. A total of 69 seed cane plots in 24.50 ha area was maintained in fields of 42 farmers (Fig.10.1).

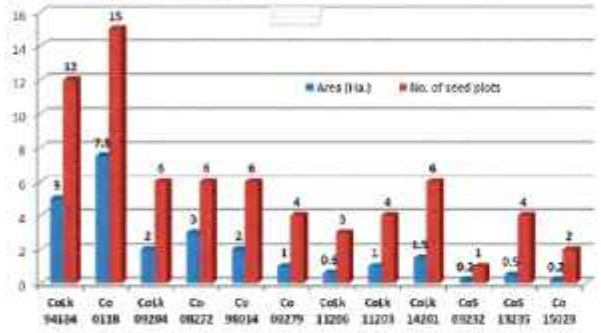


Fig. 10.1. Area (ha) and no. of seed cane plots under different varieties (2020)

The entrepreneurship training for beneficiary farmers was organised in the month to provide information in seed cane crop raising, new cane varieties, motivate farmers for enterprising in cane seed 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 (30) was collected on a 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 and achievement motivation to develop an entrepreneurial behaviour index (EBI) as presented in Table 10.1.

The overall EBI was increased by 32.67%, however, the maximum increase of 52.87% was recorded in Achievement Motivation attribute of Entrepreneurial Behaviour. The considerable increases in all the attributes of EB was recorded, which was helpful in enhancing entrepreneurial spirit among farmers.

Table 10.1. Entrepreneurial behaviour index of farmers (n=30)

S. No.	Attributes	Entrepreneurial behaviour index (%)		% Increase	Rank
		Pre	Post		
1	Risk taking	56.80	72.40	27.46	VIII
2	Hope of success	54.60	68.60	25.64	X
3	Persuability	51.50	69.70	35.34	II
4	Manageability	56.25	73.20	30.13	VII
5	Self confidence	53.20	71.40	34.21	III
6	Knowledgeability	58.25	76.50	31.33	V
7	Persistency	52.50	66.80	27.24	IX
8	Feedback Usage	53.50	70.70	32.15	IV
9	Innovativeness	5270	68.70	30.36	VI
10	Achievement motivation	48.80	74.60	52.87	I
Entrepreneurial Behaviour Index		**52.88**	**70.65**	**32.67**	

Seed cane yield, utilization and economics

Seed cane of 11 varieties *viz.*, CoLk 94184, CoLk 09204, , CoLk 11203, CoLk 11206, CoLk 14201, Co 98014, CoPk 05191, Co 0118, Co 08272, Co 08279 and CoS 09232 raised in 55 seed cane demonstration plots covering 23.50 ha area, of 40 farmers in 20 villages in Sitapur, Lakhimpur Kheri, Hardoi, Farrukhabad and Ballia districts of U.P. Autumn seed cane was raised in 22 ha area and 52 seed cane plots, wheras spring cane was raised in 1.5 ha and 3 seed cane plots. The crop was raised with practices recommended for seed cane crop. The average yield obtained for seed cane of different varieties varied from 98 to 120 t/ha (Table 10.2). However, the average seed cane yield for all the varieties was 108.64 t/ha. A total of 2633.70 tonne seed cane was produced out of which 60.72% (1599.3 t) was utilized as seed either through sale to other farmers or on own farm to raise seed cane crop in order to multiply seed of new varieties and rest of the harvested cane *i.e.* 1034.4 t (39.28%) was supplied by farmers to sugar mill/jaggery unit for crushing.

The average profit and B:C ratio for seed cane was

Table 10.2. Seed cane yield, seed cane production & utilization, economics of seed cane crop (planted in 2019-2020 and harvested in 2020-2021)

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 @ 4000 /t	Crushing @ 3250 & 3150/t	Total	
CoLk 94184	110	682	400 (58.65)	282 (41.35)	258060	147826	405886	285886
Co 0118	**120**	**780**	**550 (70.51)**	**230 (29.49)**	**338448**	**115011**	**453459**	**333459**
CoLk 09204	108	324	150 (46.30)	174 (53.70)	200016	182688	382704	262704
Co 08272	108	216	190 (87.96)	26 (12.04)	379987	52013	432000	312000
Co 98014	116	232	130 (56.03)	102 (43.97)	259979	165767	425746	305746
CoPk 05191	118	118	0 (0)	118 (100)	0	371700	371700	251700
Co 08279	**98**	**147**	**70 (47.62)**	**77 (52.38)**	**186670**	**161697**	**348367**	**228367**
CoLk 11206	102	61.2	42 (68.63)	19.2 (31.37)	280010	100792	380802	260802
CoLk 11203	104	20.8	20.8 (100.0)	0 (0)	416000	0	416000	296000
CoLk 14201	105	31.5	31.5 (100.0)	0 (0)	420000	0	420000	300000
CoS 09232	106	21.2	15 (70.75)	6.2 (29.25)	299980	100766	400746	280746
All varieties	**108.64**	**2633.7**	**1599.3 (60.72%)**	**1034.4 (39.28%)**	**263865**	**138690**	**402555**	**282555 (B:C-2.35)**
Conve-ntional	75	0	0	75 (100%)	0	243750	243750	**143750 (B:C-1.44)**
Percentage increase in net profit of the farmers								**96.56**
*Production cost @ ₹ 1,20,000/ha (for seed cane crop) & ₹ 1,00,000/ha (for conventional method)								

₹ 2,82,555 per ha and 2.35, respectively. The average profit ₹ 1,43,750 per ha and B:C ratio of 1.44 was recorded under conventional method in the study areas. The maximum profit of ₹ 3,33,459/ha was obtained for variety Co 0118 and minimum was for CoS 08279 *i.e.* ₹ 2,28,367/ha. The highest yield and utilization for seed purpose was the reason behind maximum profit for variety Co 0118. The cane varieties Co 0118, CoLk 94184, CoLk 14201 and CoLk 11203 are gaining popularity among farmers and hold good promise for replacement of Co 0238, which is now slipping out of farmers' favour due to heavy pest and disease infestation.

Collaborating Programme on Public-Private-Farmer Partnership (PPFP) model in sugarcane

To harness potential, Public-Private-Farmer Partnership (PPFP) model was developed and implemented. The outcome of the programme is very encouraging. 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. The model is the outcome of the Memorandum of Understanding (MoU) between ICAR-IISR, Lucknow and DCM Shriram Limited, New Delhi for the collaborative programme on "Doubling Farmers' Income" initiated in four sugar mills of DCM Shriram Limited. The original MoU was signed on 19th August, 2017 at ICAR-IISR, Lucknow.

As per MoU, the collaborative programme is to be implemented from 20 villages (5 villages in each of 4 sugar mills till 31st July 2024.

Operational area of the programme:

The operational area consists of five selected from villages each of 4 sugar mills. The names of villages are given in box.

1. DSCL Sugar- Ajbapur, District- Lakhimpur Kheri

   Selected villages- Ajbapur, Mahmoodpur Bhagat, Jasmadi, Mastipur and Jalalpur Gopi

2. DSCL Sugar-Rupapur, District- Hardoi

   Selected villages- Munder, Kanhari, Amirta, Timirpur and Rawatpur

3. DSCL Sugar-Hariawan, District- Hardoi

   Selected villages- Hariawan, Ahmdi, Kayampur and Jiyo, Kuiyan

4. DSCL Sugar- Loni, District- Hardoi

   Selected villages- Loni, Nagla Bhagwan, Dharmapur, Nagla Kallu and Rebha Muradpur

Baseline survey in the villages is being conducted to assess the current scenario with respect to yield, income, demography, resource condition *etc.* The PRA tools were implemented to assess the resource conditions of the villages.

Technology assessed on farmers' fields

1. PGR technology in sugarcane

The application of PGR in sugarcane was experimented *upon.*

The treatments given were setts soaking in Ethrel @ 100 ppm (25 ml/100 litres) for 24 hrs before its planting. Foliar spray of 200 ppm Ethrel at 25 DAP. Cane variety- CoLk 0118.

In autumn planted sugarcane, increase of 38.10, 30.43 and 38.66 per cent in germination, initial shoot population and tillers count, respectively was recorded (Table 10.3). Increase in growth parameters like cane lenth (10.22%) and cane girth (17.78%) was also observed. An increase of 61.97 per cent in cane yield was recorded which culminated into an increase in profit 82.28 per cent. However, the application of ethrel was found beneficial in enhancing quality parameters as increase in pol (4.06% in juice and 4.07% in cane) was observed. The sugar recovery of 11.65 per cent and 11.00 per cent in treated and control was recorded, respectively.

2. Intercropping in sugarcane

Intercropping technology was demonstrated in farmers' fields to assess its impact on enhancing yield under real farming situations. In the year 2019-2020 . 13 intercrops with autumn/spring cane (vegetable pea, potato, tomato, mustard, lentil, chickpea, cabbage, cauliflower, pigeonpea, garlic, french beans, mungbean and banana) was demonstrated.

The highest profit ₹ 4,64,500 ha with B:C ratio 2.58 was recorded by tomato grown as intercrop with sugarcane and the lowest profit ₹ 207500 ha with B:C ratio 1.48 was earned by the farmers with mustard. The profit for all intercrops was much higher than the profit recorded at sole cane crop *i.e.* ₹ 1,60,000 ha (Table 10.4). This establishes intercropping with sugarcane as profitable comparison to sole crop.

Table 10.3: Autumn planting with two bud setts in October 2019 (Co 0118) and harvested in September 2020

Growth parameters	Control	Treated	% increase
Germinaiton (%)	42	58	38.10
Initial shoot population at 45 DAP (ha)	50600	66000	30.43
Tillers count at 180 DAP (ha)	150000	208000	38.66
Net millable cane (lac/ha)	130000	190000	46.15
Cane length (cm)	186	205	10.22
Cane girth (cm)	9	10.6	17.78
Cane yield (t/ha)	142	230	61.97
Gross return (₹/ha)	461500	747500	61.97
Net profit (₹/ha)	341500	622500	82.28
B: C ratio	2.85	4.98	74.74
Pol	16.00	16.65	4.06
Pol % in cane	13.50	14.05	4.07
Recovery %	11.00	11.65	5.91

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

Six trials on three varieties *viz*, CoLk 11203, CoLk 14201 and CoLk 94184 (two trials of each) were conducted on grower's field in Patna and Majhia villages of Kumbhi Sugar. In two trials on variety CoLk 11203 covering 0.184 hectare area using 10.01 quintal seedcane was observed germination of 70 %, tillers 1,12,500, 93, 000/ NMC ha, average height 213 cm. with average girth 7.375 cm. In case of variety CoLk 14201, two trials covering 0.413 hectare area were conducted and performances observed as germination 77.5%, No. of tillers 1,20,500/ha, cane 1,00,000/ha, average height 217 cm with average girth 8.25 cm. Excellent germination, good ratoonability, no lodging tendency Just like CoS 8436, small internodes, but its length found increased in well irrigated condition. The performance of two trials on CoLk 94184 covering 0.558 hectare area using 30.1 quintal seed cane was observed as germination 74.0 %, No. of tillers 116000/ ha. No. of millable cane 95,500/ha, average height 208.5 cm. and average girth of 6.875 cm. No lodging tendency was noticed.

An analysis of gender perspective in sugarcane cultivation

A composite data collection tools has been prepared, pre-tested among the non sample farmers and finalized after incorporating the required modification. Selection of district, reserved mill zones and villages is finalized and data from few respondents were collected through telephone calls.

Technology and information utilization pattern among the sugarcane growers

An inventory of different media/channels *i.e.* WhattsApp, e-mails, phone calls, print media/literature, Radio, T.V., *Kisan Gosthi, Kisan Mela* and exhibition *etc.* being used by the sugarcane farmers for obtaining information related to sugarcane production, marketing and consumption) has been prepared. Information related to high yielding variety, insect-pest and disease management and other information related to sugarcane was provided through, WhattsApp, telephonic calls, messages, internet and technology folders among the farmers and other stakeholders of sugarcane. The data shows that more than 90 per cent farmers acquired information related to availability of HYV of sugarcane followed by insect and pest management.

Table 10.4 Economic analysis of intercrops grown with sugarcane

Cropping system	Yield (t/ha)		Net Profit (₹ ha)	B:C Ratio
	Cane	Inter crop		
Sole Sugarcane	80	-	160000	1.6
Intervention- Intercropping in sugarcane				
Sugarcane + vegetable pea	85	7.0	**262250**	**1.87**
Sugarcane + potato	85	28.0	**402250**	**2.87**
Sugarcane + lentil	86	1.6	**221350**	**1.58**
Sugarcane + chickpea	87	1.95	**224650**	**1.60**
Sugarcane + mustard	86	1.70	**207500**	**1.48**
Sugarcane + pigeonpea	86	2.0	**249500**	**1.78**
Sugarcane+cabbage	90	20.0	**352500**	**2.35**
Sugarcane+cauliflower	90	20.0	**322500**	**2.15**
Sugarcane+garlic	88	5.0	**436000**	**2.91**
Sugarcane+frenchbean	92	8.0	**360000**	**2.57**
Sugarcane+banana	90	35	**382500**	**2.01**
Sugarcane + mungbean	80	2.5	**300000**	**2.14**
Sugarcane + tomato	106	30	**464500**	**2.58**

Sale price (₹/q): vegetable pea- 1800; potato- 950; lentil- 5100; chickpea- 4200; mustard- 4000; pigeonpea- 5500; cabbage- 1000; cauliflower- 900; garlic- 6000; French beans- 2500; banana- 800; mungbean- 7200; tomato- 1000

WhatsApp was the most important tool followed by telephone calls by the farmers.

Testing and demonstration of developed manual multicrop planter

The prototype of developed single row manual multicrop planter was tested and demonstrated at farmer's field in 9.96 ha area in differents villages of Sitapur and Lakhimpur Kheri district of Uttar Pradesh. for sowing chickpea, lentil, mustard and peas mainly as intercrop (Table 10.5 and Fig. 10.2). 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 hole observed and in case of lentil, chickpeas and peas, every grooves/cell picks only one seed and drops. The effective field capacity of the machine was 0.09-0.11 ha/h with field efficiency of 60-68%. Farmers were much convinced and appreciated this machine for intercrops sowing.

Breeder seed production at farmers' field : Three tiers system for Seed Production Programme were adopted by three farmers who produced breeder seed at Narkatiaganj (Bihar) (Fig. 10.3). The breeder seed production is being carried out at Bihar farmers field since 2016-17, 2017-18, 2018-19, 2019-20 in an area of seven hectares under National Food Security Mission (NFSM). During 2020-2021, sugarcane seed for an area of 3 ha was supplied to farmers of Bihar under the BSP programme component of NFSM..

Fig.10.2 FLD of manual multicrop planter in different villages

Table 10.5 FLD of manual multicrop planter at farmers' field

S.No.	Name of the farmer	Village	Area sown (ha)	Crop sown
1.	Ramnaresh	Padariya	0.56	Lentil
2	Puttilaal	Leelapurwa	0.24	Lentil
3	Indrawati	Seikhwapur	0.40	Lentil
4	Dalvinder	Amaura	1.20	Lentil
5	Kailaash Chandra	Ramnagra	0.80	Lentil , Mustard
6	Krishna Kumar	Banni Purain	0.32	Gram, Pea
7	Sudhir Kumar	Banni Purain	0.32	Lentil, Mustard, Gram
8	Premchandra	Shivpuri	0.40	Lentil, Mustard, Gram
9	Hazarilaal	Naseerpur	0.48	Gram
10	Manoj Kumar	Virahimapur	0.40	Gram, Pea
11	Sangeeta Devi	Banni Rai	0.80	Lentil , Mustard
12	Maanpur farm	Maanpur	2.00	Gram, Pea, Lentil
13	Ashok	Mahmoodpur Khurd	0.64	Gram , Mustard
14.	Malkhan Singh	Harsinghpur	0.80	Mustard , Pigeonpea
15.	Deependra Singh	Era Lakhimpur	0.60	Mustard
		Total	**9.96**	

Frontline Demonstrations

IISR tractor operated 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 10 farmers fields. Effective field capacity of the equipment was 0.30-0.35 ha/h. Farmers were satisfied with the performance of the machine. Based upon the feedbacks of the farmers, fertilizer metering power transmission was modified.

Fig.10.3 IISR two row disc type RMD management device

IISR tractor operated deep furrow sugarcane cutter planter

IISR tractor operated deep furrow sugarcane planter was demonstrated at farmers field of Shahjahanpur, Lakhimpur Kheri and Kushinagar districts of Uttar Pradesh in 12.5 ha area. Planter under field operation is shown in Fig 4.5. Total 15 farmers used the planter. The performance of the planter was satisfactory for planting of sugarcane (including sett cutting) at farmer's field. Cost of planting operation was ₹ 3,500 per ha using the planter as compared to ₹ 8,500 per ha in conventional method.

Fig. 10.4 IISR deep furrow sugarcane planter

IISR tractor operated sugarcane trench planter

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

Fig. 10.5 IISR sugarcane trench planter in field operation

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

IISR tractor operated raised bed seeder-cum-sugarcane planter was operated at farmer's field at Biswa sugar mill area of Sitapur district in 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. 10.6 IISR deep furrow sugarcane cutter planter in field operation at Manpur, Sitapur

Mmultipurpose interculturing equipment

IISR tractor operated multipurpose interculturing equipment was used for interculturing in inter-row spacing and simultaneously spraying of herbicides in intra-row spacing of sugarcane.

Equipment was demonstrated at farmers field of Sitapur district. Total of 5.2 ha area was covered covering 15 farmers. Farmers were satisfied with the performance of the equipment.

Fig. 10.7 IISR Tractor operated multipurpose interculturing equipment in field operation

Frontline demonstrations on seed cane

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, Hardoi, Pilibhit, Farrukhabad and Ballia districts of Uttar Pradesh. Seed cane crop of varieties CoLk 94184, Co 0118, CoLk 09204, Co 98014, CoS 08272, CoS 08279, CoLk 11203, CoLk 11206, CoS 09232, CoS 13235, Co 15023 and CoLk 14201 was raised in demonstration fields with recommended package of practices.

To popularize intercropping of pulses, vegetables, oilseeds *etc.* with sugarcane and economize the use of seed rate, a total of 30 nos. of FLDs on intercropping with sugarcane and bud chip technology was conducted on total of 24 ha area in Uttar Pradesh.

Mera Gaon Mera Gaurav

Fourteen multidisciplinary teams of the scientists of ICAR- IISR, Lucknow adopted eight villages under the scheme "*Mera Gaon Mera Gaurav*" in four DSCL sugar mills namely Rupapur, Hariawan and Loni in Hardoi district and Ajabapur in Lakhimpur Kheri district of Uttar Pradesh and one team of three

scientists at Pravaranagar, Maharashtra .

Transfer of technology related to jaggery manufacturing

- Eleven IISR 3 pan jaggery unit were established.
- One hundred moulding frames were sold to entrepreneurs.
- Value added jaggery technology was transferred to four entrepreneurs.
- Improved jaggery making technology has been demonstrated to visitors at several occasions.
- Requests for establishment of Jaggery plant has been received from Samastipur, Bihar; IGKVV, Raipur, Chhattisgarh; PAU, Ludhiana, Punjab and KVK, Mizoram.
- Organized three-day quality jaggery making demonstration at KVK, Chowki Makhi, Gorakhpur, Uttar Pradesh for 50 farmers from 04-06 Feb, 2020
- Organized one day quality jaggery making demonstration at ICAR-IISR Regional Centre, Motipur, Bihar for 25 farmers on December 10, 2020.
- Organized one day Technology Demonstration *Mela* on February 15, 2020 at ICAR-IISR, Lucknow, Uttar Pradesh.

Transfer of technology related to sugar beet

The sugar beet seeds of different varieties were supplied to National Sugar Institute, Kanpur, Uttar Pradesh for evaluating ethanol content. Eight sugar beet varieties with high sucrose content were sent to ARS, Basanthpur, Telangana; BCKV, Kalyani, West

Bengal, SKUAS&T, Jammu & Kashmir) and two varieties were sent to *Shiksha 'O' Anusandhan*, Khordha, Odisha for research purposes. With an objective to commercialize sugar beet production among farmers, a total of four varieties were furnished to the Parle Group Company, Bahraich, Uttar Pradesh. Similarly sugar beet seeds were also given to farmers of Hardoi, Uttar Pradesh under doubling farmer's income for popularizing and increasing farmer's income. The seeds of LS 6 variety were supplied to Animal Breeding Research Organization, Karnal, Haryana for its utilization in fodder purposes.

MoAs signed

The ICAR-IISR signed new MoU with sugarcane Industries Department, Government of Bihar for Breeder Seed Production (>11.0 crores budget) during 2019-20 to 2023-2024 at different sugar mills of Bihar.

Three MoA were signed with following entrepreneurs:

- Sri Sant Ram Dixit, Jan Sewa Ashram, Fatehpur, Uttar Pradesh
- M/s NATUREGAON, Meerut, Uttar Pradesh
- M/s Shandilya Agro Industries, Azamgarh, Uttar Pradesh

Entrepreneurship in operation and maintenance of sugarcane machine

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 on February 27-28, 2020. A group of farmers was created to develop them as entrepreneur in machine maintenance and operation.

Linkages developed

Collaboration with *Shukla Bandhu Organic Producer Company Limited*, Biswan, Sitapur (U.P.) was initiated to establish a "Sugarcane-based Model Farm" at Purwa Dasapur, Sitapur, Uttar Pradesh for promoting agribusiness among rural youth.

Linkage with Mahindra & Mahindra and General Aeronautics was established for pilot project on Drone use in Sugarcane.

Entrepreneur farmer developed

Four farmers were developed as entrepreneur and they are doing seed cane business. They are now recognized by state department/AIR/DD and inviting them to share their experience on success achieved.

Field day organized- 03

1. 27th February, 2020 at Shankarpur, Sitapur (U.P.)
2. 23rd September 2020, Biswan, Sitapur (U.P.)
3. 23rd November, 2020, Hasanpur (Bihar)

Exhibition organized

Date	Place	Programme	Total no. of visitors
January 31 to February 2, 2020	VSI, Pune	2nd International Conference and Exhibition	800
February 16, 2020	ICAR-IISR, Lucknow	IISR Foundation Day	300
February 26, 2020	ICAR-CISH, Lucknow	Farmers' Fair	250

CHAPTER 11

Krishi Vigyan Kendra, Lucknow

Frontline Demonstrations:

I) Crop	Area (ha)	No. of demonstrations
Cereal		
Wheat (HD 2967)	0.5	1
Paddy	1	20
Total	**1.5**	**21**
Pulse		
Field pea (HFP 529)	20	242
Chick pea (Ujwala)	10	116
Chick pea (GNG 2144)	10	55
Green gram (IPM 2-3)	10	47
Black gram (KUG 479)	10	56
Total	**60**	**516**
Oilseed		
Mustard (Giriraj)	104	346
Toria (Uttara)	10	49
Sesamum	10	31
Total	**124**	**426**
Vegetables		
Vegetable pea (Kashi Uday)	6.0	53
Onion (Agrifound light red)	1.0	11
Broccoli (Fantasy F1)	1.0	10
Red Cabbage (Super Red 115)	0.5	5
Cowpea (Zaid-2020)	1	9
Cowpea (*Kharif*-2020)	1	15
Tomato: Brinjal: Chilli	10	10
Potato (Disease and insect management)	4	16
Tomato (US 2853)	5	42
Bottle gourd (Use of fruit fly trap)	5	12
Mango (Use of fruit fly trap)	10	17
Total	**46.5**	**205**
Others		
Hybrid Sweet Sorghum (CSH 24MF)	05	63
Perennial Fodder Grasses (Hy. Naiper)	01	10
Perennial Fodder Grasses (Guinea)	01	10
Barseem (Mescavi & JHB 146)	10	88
Oat (Kent)	2	51
Barseem (Mescavi) under SCSP	18	243
Oat under SCSP	9	147
Nutritional Kitchen Gardening (2019-20)	2-14 family member	79
Nutritional Kitchen Gardening (*Kharif*-20)	3-11 family member	100
Basket Making	0	10
Bag Making	0	10
Total	**46.0**	**811**
Grand Total	**278.0**	**1979**

II. Livestock	No. of animals/Farmers	No. of demonstration
Buffalo (UMMB)	15	50
Dairy (Deworming of Cows and Buffalos)	215	52
Vermi composting	06	06
Total	**236**	**108**

Training

Area of training	No. of courses	Farmers training			Vocational training			Extension functionaries		
		M	F	Total	M	F	Total	M	F	Total
Horticulture	17	360	33	393	0	0	0	0	0	0
Livestock production and management	21	405	9	414	0	0	0	0	0	0
Home Science/women empowerment	17	0	462	462	0	0	0	0	0	0
Plant protection	15	272	18	390	0	0	0	0	0	0
Capacity building & group dynamics	2	48	0	48	0	0	0	0	0	0
Others (Button Mushroom Production)	4	0	0	0	86	9	95	0	0	0
Preservation and Value Addition	01	0	0	0	0	21	21	0	0	0
Inservice Training Programme	04	0	0	0	0	0	0	48	42	90
Total	**81**	**1186**	**574**	**1760**	**86**	**30**	**116**	**48**	**42**	**90**

Technology assessment and refinement

Thematic Area	Name of Crops/Enterprises	No. of Technology	No. of On Farm Trials	No. of Trials
INM	Potato	Integrated Nutrient Management	05	05
IPM	Mango	Management of thrips	03	05
IDM	Vegetable Pea	Disease management	03	05
Drudgery reduction	Wheel hand hoe	Use of wheel hand hoe by farm women	15	15
Post harvest management	Value Addition	Preservation of vegetable pea	10	10
Total	**05**		**36**	**40**

Livestock

Thematic Area	No. of Technology	No. of on Farm Trials	No. of animals
Animal Health Camp for cow/buffalo	Deworming of animals	1	430
Others	Performance of sugar rich green fodder round the year	15	15
Total		**16**	**445**

Extension activities conducted

Activities	No. of programmes	No. of farmers	No. of Extension personnel
Advisory services	150	200	0
Diagnostic Services	23	23	0
Kisan gosthi	16	1197	6
Farmers fair	2	630	20
Exhibition	2	650	12
Scientists' visit to farmers field	281	2159	8
Farmers visited to KVK		1016	5
Lecture delivered	51	2367	15
Animal health camps	1	430	07
Mobile advisory	2858	20012	27
Radio talk	5	0	0
Farmers' seminar/workshop	3	120	0
Method demonstrations	19	398	0
Kisan Diwas	1	110	19
Live telecast programme (PM *Kisan Samman Nidhi*)	1	320	25
Workshop and Farmers fair on Rooftop kitchen gaden	1	500	50
Poshan Maah Abhiyan	01	203	23
Mahila Kisan Diwas	01	93	6
World Food Day	01	45	5
World Soil Health Day	01	45	12
Total	**3,418**	**30,518**	**240**

SMS sent to farmers

Category	No. of SMS	No. of farmers
SMS Sent to farmers	29	1,03,2520

Other extension activities

Particulars	Number
Extension literature	09
News paper coverage	12
Technical reports	15
Radio talks	03
Animal health camps	01
(Number of animals treated)	(430 Animals were treated)
Total	**40**

Seed and planting material production

Seed production

Crop	Quantity (q)
Cereal	
Wheat (HD-2967)	120
Paddy (PB-1637)	50.
Total	**170**
Pulse	
Chickpea (Ujjwal)	10.
Pegionpea (NDA-2)	10.
Total	**20**
Oilseed	
Lin Seed	1
Total	**01**
Grand Total	**191**

Planting material production

Crop	No./Kg. of planting materials
Fruit saplings	
Lemon	200
Moringa	250
Mango (Grafted)	1,735
Mango (Root stock)	40,000
Guava (Root stock)	10,000
Papaya	
Total	**52,185**
Vegetable seedlings	
Onion	50,000
Colocasia	250 kg.
Elephantfoot yaan	500 kg.
Onion	100 kg. Bulblets
Total	**50,000 and 850 kg.**
Spices	
Turmaric	300 kg.
Garlic	30 kg.
Total	**330 kg.**
Ornamental	
Total	
Other saplings	
Root Slips of different	1,000
Perennial Fodder Grasses	
Total	**1,000**
Grand Total	**1,20,185**

Other production

Products	Quantity (kg)
Vermi compost	804
Mushroom	170
Cow calves	02
Mango Pickle	130.5

Soil testing

Samples	No. of samples tested
Soil	300

Training programme on production of button mushroom under ARYA project

Compost preparation by trainees

Assessment of root rot and powdery mildew disease management in vegetable pea

Assesment of thrips management in mango orchard

Assessment of integrated nutrient management in potato

Assessment and feasibility of preservation of vegetable pea

Assessment of hand wheel hoe for reduction of drudgery of farm women

FLD on sweet sorghum

CHAPTER 12

Krishi Vigyan Kendra-II, Lakhimpur Kheri

ICAR-Krishi Vigyan Kendra-II, Majhara Farm Lakhimpur Kheri has been functioning since 11th August, 2020.

On Farm Trials (OFTs)

Two 'On Farm Trials' were conducted :

Intercropping of garlic in sugarcane crop

An on-farm trial on performance evaluation of intercropping of garlic in sugarcane crop conducted at three farmers fields, revealed that farmers gained extra income of ₹ 20,270/acre over farmer practices.

Evaluation of CARI-Shyama and CARI-Nirbhik poultry bird

Results of the OFT revealed that the maximum number of eggs (165) were recorded in CARI-Shyama followed by CARI-Nirbhik (160) as compared to local breed with 70 eggs/year.

Frontline Demonstrations (FLDs)

Two frontline demonstrations on sugarcane were conducted. The salient achievement are as follows:

1. Deep furrow cutter planter in sugarcane cultivation: Results revealed that the implement reduced time (3 hour/acre) and expenditure (₹ 4,000 acre) as compared to the farmers practice (8 hours/acre) and expenditure (₹ 5,000 /acre).

2. Sugarcane Cv. CoLK 11206

Varietal demonstration on CoLk 11206 was conducted at four farmers fields Ten q of sugarcane setts were given to each farmer. The result revealed that maximum yield was obtained as compared to farmers' practices (1025 q/ha).

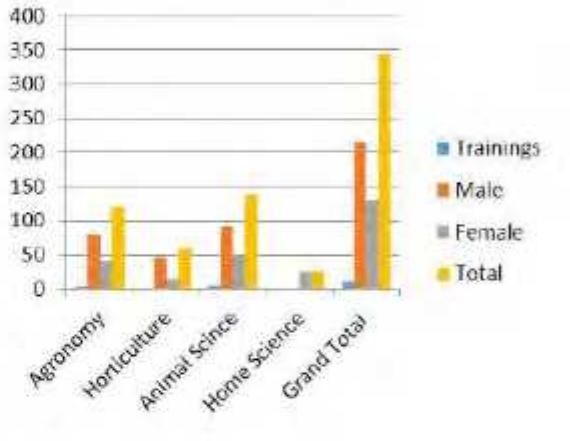
Crop	demonstrations technology demonstrated	No. of farmers	Area (ha)	Yield (q/ha)		% Increase
				Demon	Check	
Chickpea	JG 14	80	3.9	14.40	9.10	36.80
Sugarcane	CoLk 11206	04	0.53	1200	1050	14.28
Broccoli	NH Hybrid 50	02	0.06	13.3	11.0	20.90
Pea	Kashi Adarsh	12	0.02	*	*	*
Lentil	UPL 402	09	0.10	*	*	*
Pigeonpea	Narendra Arhar 02	02	0.15	*	*	*
Paddy	Kashi Sugandha	02	0.50	42.21	38.42	09.8

* Results awaited.

TRAININGS

Total 11 training programmes (vocational and in-service) were conducted of which three were "On campus" and 8 were conducted "Off campus", by the concerned Subject Matter Specialist in the

collaboration with the Institute, line departments of Lakhimpur Kheri. Total 344 persons were trained including practising farmers, rural youth/farm women, SHGs and the extension functionaries.



Extension Activities conducted

Activity	Date	No of participants
Intregrated nutrient management	03/01/2020	36
Murgi Palan Paathsahala	01/02/2020 & 25/08/2020	73
Urvarak Prayog Evam Mrida Swasthya Prabandhan	03/02/2020	21
Soil health and testing	10/02/2020	53
Murgi Palan Hetu Prashikshan Kaarykram	18/02/2020	30
Gahre Kun Mein Ganna Bone Hetu Pradarshan	05/03/2020	44
Pradhan Mantri Garib Kalvaan Abhivaan	20/06/2020 & 07/07/2020	90
Hindi Diwas	14/09/2020	58
Rashtriya Poshan Maah	19/09/2020	20
Potato seed distribution	14/10/2020	33
Mahila Kisan Diwas	15/10/2020	115
Mechanization of sugarcane cultivation	28/11/2020	51
Agriculture Education Day	03/12/2020	68
World Soil Day	05/12/2020	70
Murgi Palan Sangosthi	09/12/2020	50
Kisan Diwas	23/12/2020	98
Atal Sushasan Diwas	25/12/2020	74
Total		984

Glimpses of Extension Activities

Farmers agro-advisory services

Advisory in Crop	Number of Advisories	Number of farmers
Sugarcane	35	140
Rice	24	44
Mustard	15	69
Wheat	21	71
Pea	15	44
Vegetable crops	63	132
Fruit crops	43	78
Grand total	**216**	**578**

Planting material production

Planting material	Number	Distributed to farmers (No.)	Value (₹)
Brinjal	200	10	200
Tomato	200	14	200
Total	**400**	**24**	**400/ -**

Soil testing

Number of soil samples tested and soil health card distributed	:	57

CHAPTER 13

Services to the Industry

Contract Research Project

ICAR-IISR, Lucknow carried out the evaluation of new industrial products which have to be used in sugarcane cultivation. The evaluation of products includes insecticides, pesticides, fungicides and other chemical formulations. The evaluation was carried out by 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
BASF India Ltd., Navi Mumbai	Evaluation of bioefficacy and phytotoxicity of pre-emergence application of two herbicides *viz*, BAS 78102 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. Holkar, D.N. Borase and Y.E. Thorat; 04/2018-03/2021, Budget : ₹ 15.0 lakh)
BASF India Ltd., Navi Mumbai	Evaluation of bio efficacy and phyto-toxicity of pre-emergent application of Saflufenacil 68 g/1 + Dimethenamid-P 600 g/1 EC (Integrity 668 g/1 EC) against weeds in sugarcane and its effects on succeeding crop (S.K. Holkar, D.N. Borase and Y.E. Thorat, 04/18-03/20; 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)
Bayer Crop Science Ltd., Mumbai	Bio-efficacy of Vayego Superb (Tetraniliprole 0.4% + Fipronil 0.6% Gr against early shoot borer, top shoot borer and white grub in sugarcane (M.R. Singh and Arun Baitha; 05/18-05/20; Budget : ₹ 10.0 lakh)
United Phosphorus Ltd., Mumbai	Bio-efficacy 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	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 Rs. 10.0 lakh)
Narmada Biochem Limited	Assessing efficacy of Narmada PROM (Phosphorus rich organic manure) as an organic source of P on soil quality and productivity of cane and sugar in Indian sub-tropics (S.N. Singh, A.D. Pathak, V.K. Singh 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; 05/19-04/21, 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; Budget : ₹ 20.0 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	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 : ₹ 10.00 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)
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)

Chapter 14

Human Resource Development

Training Programme on Administrative and Financial Matters

A three day "Training Programme on Administrative and Financial Matters" aimed for the administrative personnel working in ICAR to develop their skills in the era of technical development, was organized by the ICAR-Indian Institute of Sugarcane Research, Lucknow during March 03-05, 2020 under Human Resource Development policy of the Council. The training programme was inaugurated by Dr. A.D. Pathak, Director IISR, Lucknow on 3rd March, 2020. The entire training programme was coordinated by Sh. S.K.Singh Senior Administrative Officer and Dr. Sangeeta Srivastava, Principal Scientist and HRD Nodal Officer who were also the key lecturers. The various topics related to administration and finance like, Noting & Drafting, Procurement through GeM, Procurement through CPPP, Salient features of the GFR – 2017, Preventive vigilance, Time management, effective use of online tools (FMS, ERP, GeM, CPPP, e-Office), office automation and moving towards paperless office and prevention of sexual harassment at workplace *etc.*, were covered during three days. In his valedictory address on 05th March, 2020, Dr. A.D.Pathak, Director, IISR Lucknow emphasized upon the skill development through a regular practice of learning and by updating knowledge on relevant rules and regulations as both the administration and finance are the two peer, of the organization. Later, Sh. S.K.Singh, Sr. Administrative Officer & Master Trainer briefed about the well-organized training policy of HRM Division of the Council and a panel of Master Trainers throughout the country. He urged upon the development of skills in this technical age where most of the things are going to be online and updation of knowledge in terms of rules and regulations for administration personnel. Dr. Sangeeta Srivastava, HRD Nodal Officer appreciated the programme and suggested to organize more trainings on the skill development and urged upon development of knowledge ecosystem in all categories of staff which in turn will result for the betterment of the organization. The training programme was concluded with vote of thanks by Sh. Saroj Kumar Singh, Sr. Administrative Officer & Head of Office. Total 36 participants from different Institutes participated in the training programme.

Training organized

Name of Training	Name of the Scientists	Period	Venue
Orientation Programme of ARS 110th FOCARS batch Coordinator: Dr. Sangeeta Srivastava	• Mr. Aalok Shiv • Ms. V. A. Blessy • Ms. Manisha Saini • Dr. Rajesh Uttreshawar Modi • Mr. Nenavath Krishna Kumar Rathod	July 27-August 31, 2020	ICAR-IISR, Lucknow and KVK, IISR, Lucknow
Brain Storming Session on "Nano Technology Application in Sugarcane" Coordinator: Dr Pushpa Singh	All Scientists of the Institute	January 10, 2020	ICAR-IISR, Lucknow

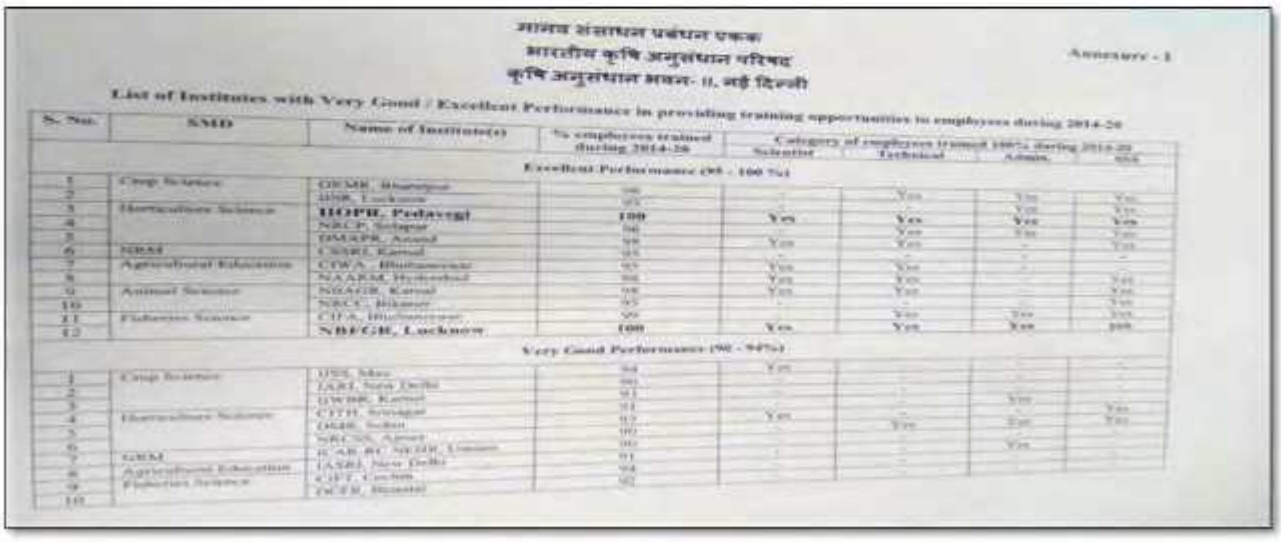
Training received (Online/Offline)

Name	Training Programme	Venue/Organizer	Date
Dr.Veenika Singh	National Training on Intercropping in Sugarcane	ICAR-IISR, Lucknow	February 11-12, 2020
Dr. Varucha Misra	Training on Conservation Agriculture-based Sustainable Intensification	IIT, Kanpur and Commonwealth of Learning, Canada	February 12-March 31, 2020
Dr. Deepak Rai and Dr. Viveka Nand Singh	National Training on Intercropping in Sugarcane	ICAR-IISR, Lucknow	February 18 -19. 2020
Dr. S.K. Goswami	Training on "Production of Value Added and Fortified Microbial Compost and Microbial Inoculants Technologies for Use in Agriculture	ICAR-NBAIM, Mau	February 25-29, 2020
Dr. Sangeeta Srivastava	Training on E Office	ICAR-IISR, Lucknow	May 12, 2020
Dr. A. K. Mall	Webinar on Genomics for Food Health and Nutrition	ICRISAT, Hyderabad	May 14, 2020
Dr. Sukhbir Singh	Online International Training on "Present and Futuristic Trends in Agricultural Mechanization	VNMKV, Parbhani, Maharashtra	June 18 - 23, 2020
Dr. Sangeeta Srivastava	*Hindi Workshop* on Use of e-Office,	ICAR-IISR, Lucknow	June 29, 2020
Dr. Sukhbir Singh	Online Training on "Ergonomical Design Guidelines for Agricultural Tools and Equipment"	ICAR-CIAE, Bhopal	June 29 - July 03, 2020
Dr. Varucha Misra	Online National Level Lecture Series on "Agricultural Biotechnology"	Vasantrao Naik College of Agricultural Biotechnology, Akola	July 30 – August 3, 2020
Dr. Varucha Misra	Online International Training Course on "Conservation Agriculture based Crop Management Technologies in Climate Smart Agriculture"	Centre for Advanced Agricultural Science and Technology for Climate Smart Agriculture and Water Management, MPKV Rahuri	May 18 -22, 2020
Dr. Y.E. Thorat	Online Training on 'SciCom for Smart Scholar'	ICAR-CIFE, Mumbai	May 26- June 8, 2020
Dr. Varucha Misra	National e -Training on "Indian Agricultural Education System and Entrepreneurship Scope in 21st Century"	NAHEP, DrPDKV, Akola	August 5-14, 2020
Dr. Varucha Misra	Training on Basic Microbiology	World Health Organization and Health Emergencies Programme	August 7, 2020
Dr. S.I. Anwar	Virtual Orientation Workshop and Training Programme for ABI Centres	ICAR-NAARM, Hyderabad	August 17 19, 2020

Dr. Radha Jain	Online MDP Training on IP Valuation and Technology Management	ICAR-NAARM, Hyderabad	September 1-5, 2020
Dr. L.S. Gangwar and Sh. Brahm Prakash	Virtual Workshop-cum-Training on Intellectual Property Rights in Agricultural Research & Education in India	NAHEP and IP & TM Unit of ICAR, New Delhi	September 12 - 28, 2020
Dr. Varucha Misra	Online International Training Programme on "Agriculture 4.0: Precision and Automated Agricultural Technologies"	CAASR-CSAWM, MPKVV, Rahuri	September 28 - October 2, 2020
Dr. Sanjeev Kumar (Biotech.)	Interactive Workshop for IBSCs Registered on IBK Portal	RCGM, DBT, New Delhi	November 5, 2020
Dr. M. Swapna and Dr. R.R. Verma	On-line Training Programme on Analysis of Experimental Data using SAS	ICAR-NAARM, Hyderabad	November 9-17, 2020
Dr. Mona Nagargade	Training on Nano Technology	Institute of Nano Science, Mohali	November 23 - 27, 2020
Dr. Radha Jain and Dr. Y.E. Thorat	Online Training on 'Advanced Bioinformatics Tools and its Application in Agriculture'	ICAR-NAARM, Hyderabad	December 7-11, 2020
Dr. Dnyaneshwar Borase	Training Programme on "Novel Techniques in Mass Culturing of Smart Microbial Biocontrol Agents for the Development of Biopesticides"	ICAR-NBAIR, Bengaluru	December 3-23, 2020

Performance of HRD in IISR rated excellent

Under ICAR HRM Policy: Training and Capacity Building regarding training opportunities given to various categories of employees during 2014-20, performance of ICAR-IISR was rated as Excellent and the Institute was ranked among top two Institutes of Crop Science Division (email of the Assistant Director General (HRM), ICAR, New Delhi dated November 20, 2020).



भारतीय कृषि अनुसंधान परिषद
कृषि अनुसंधान भवन- II, नई दिल्ली

Annexure - I

List of Institutes with Very Good / Excellent Performance in providing training opportunities to employees during 2014-20

S. No.	SMD	Name of Institute(s)	% employees trained (during 2014-20)	Category of employees trained 100% during 2014-20			
				Scientist	Technical	Admin.	SSS
		Excellent Performance (95 - 100 %)					
1	Crop Science	CIMMYT, Mexico	98	-	Yes	Yes	Yes
2		IIHR, Lucknow	95	-	-	Yes	Yes
3	Horticulture Science	IIOPR, Pedavegi	100	Yes	Yes	Yes	Yes
4		NRCP, Solapur	98	-	Yes	Yes	Yes
5		DMAPR, Anand	98	Yes	Yes	-	Yes
6	NRM	CSSRI, Karnal	95	-	-	-	-
7	Agricultural Education	CIWA, Bhubaneswar	95	Yes	Yes	-	-
8		NAARM, Hyderabad	98	Yes	Yes	-	Yes
9	Animal Science	NDAGR, Karnal	98	Yes	Yes	-	Yes
10		NRCC, Bikaner	95	-	-	-	Yes
11	Fisheries Science	CIFA, Bhubaneswar	95	-	Yes	Yes	Yes
12		NBFGR, Lucknow	100	Yes	Yes	Yes	Yes
		Very Good Performance (90 - 94%)					
1	Crop Science	IISR, Kozhikode	94	Yes	-	-	-
2		IARI, New Delhi	90	-	-	-	-
3		IIWBR, Karnal	93	-	-	Yes	-
4	Horticulture Science	CITH, Srinagar	93	Yes	-	-	Yes
5		IIHR, Delhi	90	-	Yes	Yes	Yes
6		NRCSS, Ajmer	90	-	-	Yes	-
7	NRM	ICAR-IISWC, Dehradun	91	-	-	-	-
8	Agricultural Education	IASRI, New Delhi	94	-	-	-	-
9	Fisheries Science	CIFT, Cochin	92	-	-	-	-
10		ICAR, Mumbai	90	-	-	-	-

Trainings organised

Skill development training

Topic of training	Number of participants	Venue	Date
Training on Quality Jaggery Making	50 Farmers	KVK, Chowk Mafhi, Gorakhpur	February 4-6, 2020
Technology Demonstration Mela	180 Farmers	ICAR-IISR, Lucknow	February 15, 2020
Training on Quality Jaggery Making	25 Farmers	ICAR-IISR, Lucknow	March 2-4, 2020
Training on Quality Jaggery Making	25 Farmers	Regional Centre Motipur, Bihar	December 10, 2020

One day training-cum-visit organised

During the period, a total of 40 nos. one day training and visit programme was organized at the Institute in which 1644 farmers, 132 development personnel, 992 students and 53 teachers acquired latest know-how in scientific cane cultivation practices, jaggery making, bio-fertilizer production, tissue culture and sugarcane machines.

Date	Sponsored by	No. of trainees
09.01.2020	Agriculture Corp. Damoh, M.P.	56 Farmers+ 2 Officers
24.01.2020	Sacred Heart School,Telibagh, Lucknow, U.P.	132 Students + 4 Teachers
27.01.2020	SADO, Satna M.P.	30 Farmers + 3 Officers
30.01.2020	Rehman Kheda, Lucknow, U.P.	27 Farmers+ 1 Officers
30.02.2020	*Pariyojana Sanchalak*	64 Farmers + 1 Officers
6.02.2020	SRIMT, BKT, Lucknow, U.P.	45 Students + 1 Teachers
10.02.2020	Godwara Distt. Narsinghpur, M.P.	64 Farmers + 1 Officers
18.02.2020	Narsinghpur, M.P.	28 Farmers + 1 Officers
18.02.2020	BIRD, Lucknow, U.P.	33 Bank Officers
19.02.2020	Up *Pariyojana Sanchalak* ATMA, Tikamgarh, M.P.	21 Farmers + 1 Officer
19.02.2020	Up *Pariyojana Sanchalak* ATMA, Tikamgarh, M.P.	21 Farmers + 1 Officer
19.02.2020	Up *Pariyojana Sanchalak* ATMA, Prithvipur, Tikamgarh, M.P.	19 Farmers + 1 Officer
19.02.2020	Up *Pariyojana Sanchalak* ATMA, Tikamgarh, M.P.	21 Farmers + 1 Officer
19.02.2020	Up *Pariyojana Sanchalak* ATMA, Jatara, Tikamgarh , M.P.	21 Farmers + 1 Officer
19.02.2020	Up *Pariyojana Sanchalak* ATMA, Shivni, Tikamgarh , M.P.	19 Farmers + 1 Officer
20.02.2020	Agriculture Department, Distt. Anooppur, M.P.	44 Farmers + 1 Officer
23.02.2020	*Gramin Mahila Evam Bal Utthan Sewa Samiti* Bhimapar Naugarh, Sidharthnagar , U.P.	22 Farmers + 1 Officer
24.02.2020	Amarpatan, Distt. Satna, M.P.	36 Farmers + 2 Officer
24.02.2020	*Gramin Sewa Samiti*,Distt. Pilibhit, U.P.	35 Farmers + 1 Officer
25.02.2020	*Up Sanchalak Krishi Karyalay*, Chhagar, M.P.	26 Farmers + 1 Officer
27.02.2020	*Up Sanchalak Krishi*, Satna, M.P.	40 Farmers + 2 Officer
27.02.2020	SRIMT, BKT, Lucknow, U.P.	120 Students + 3 Teacher
03.03.2020	*UP Sanchalak Krishi Tatha Krishi Vikas* Distt. Datiya M.P.	30 Farmers + 2 Officer

03.03.2020	*Karyalay Up Sanchalak Kisan Kalyan Tatha Krishi Vibhag*, Anuppur, M.P.	44 Farmers + 1 Officer
05.03.2020	SDAO, Distt. Satna, M.P.	40 Farmers + 3 Officers
05.03.2020	*Varishth Krishi Vikas Adhikari*	10 Farmers + 1 Officer
05.03.2020	Cho. Haran Singh P.G. College, Lucknow, U.P.	112 Students + 5 Teacher
05.03.2020	SADO, Rampur, U.P.	10 Students + 1 Teacher
05.03.2020	*Pragya Gramotthan Sewa Samiti*, Fatehpur, M.P.	36 Farmers + 1 Officer
05.03.2020	*Sahayak Krishi Sanrakshan Adhikari*, Satna, M.P.	50 Farmers + 2 Officers
16.03.2020	Department of Environmental Science, BBAU, Lucknow, U.P.	02 Students
16.03.2020	Saidpur, Ayodhya, U.P.	02 Farmers
17.03.2020	Project Director, ATMA, Rewa, M.P.	39 Farmers + 2 Officers
18.03.2020	SADO Office,Ramnagar, Satna, M.P.	10 Farmers + 1 Officer
24.09.2020	Farmer Jamarpur Kalan, Lucknow U.P.	01 Farmer
13.10.2020	Rampur Tikariya, Distt. Lakhimpur Kheri, U.P.	06 Farmers
04.11.2020	Farmer of Distt. Lakhimpur Kheri through State Agriculture Department, U.P.	35 Farmers
04.11.2020	Farmers of Hardoi and Lakhimpur Kheri,U.P.	18 Farmers
19.12.2020	P.D., ATMA, Rewa, M.P.	10 Farmers + 1 Officer
24.12.2020	Asstt. Horticulture Centre, Bhind, M.P.	07 Farmers + 2 Officers

Entrepreneurship training for promoting agri-business

The Entrepreneurship in agriculture has been identified as significant contributing factor in doubling or enhancing farm income. The Institute has applied concerted efforts under its outreach extension and training programme to impart knowledge and skills in entrepreneurship to farmers, NGO personnel, development officers, Agri-graduates and extension functionaries of different State Governments. For this, several residential and off campus training programmes were conducted in which more than 100 participants were groomed as entrepreneur & to pursue agri-business in their available farming systems.

Training and capacity building organized

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

One month to six months training was conducted in the Division of Crop Improvement and Division of Agricultural Engineering for students of B. Tech., M. Tech. and M.Sc. (Ag.) students of various Universities during January – December 2020.

Students visit under Inter-institutional HRD activities

Under inter-institutional HRD activity, conducted visits of students and teachers from SHUATS, Allahabad; BHU, Varanasi; AMITY, Lucknow; GD Goenka School, Lucknow; Sacred Heart School, Lucknow; SRITM, Lucknow; BBAU, Lucknow; NDUA&T, Faizabad; SASRD, Nagaland and other institutions. More than 500 UGs/PGs and school students visited IISR. During visit, they were imparted information on IISR research infrastructure, achievements and technologies developed through orientation lecture and visit to labs and fields.

CHAPTER 15

Awards/Honours

Govt. of India Award

Rajbhasha Patrika 'Ikshu" of the Institute has been selected for the Second Prize of *Rajbhasha Keerti Puraskar* for the year 2018-19 by the Department of Official Languages, Ministry of Home Affairs, Govt. of India.

Professional Society Awards

- Dr. Sangeeta Srivastava received Distinguished Agriculture Scientist Award-2019 of Uttar Pradesh Academy of Agricultural Sciences (UPAAS) for outstanding achievements in Crop Improvement, at BHU, Varanasi on February 24, 2020.

- Dr. Sangeeta Srivastava received SAAR Distinguished Scientist Award-Crop Sciences by Society for Agriculture & Allied Research at IAAAS 2020 at JNU, New Delhi on January 31, 2020.

- Dr. P.K. Singh was conferred with Distinguished Researcher in Plant Breeding Award for the year 2020 from Centre for Advanced Research and Design, Venus International Foundation, Chennai.
- Dr. A.K. Sah received *Harit Kranti* Award-2019 in 5th National Youth Convention on Next Generation Agri Innovations: Challenges and Opportunities for Sustainable Employment Generation in Agri and Allied Sector held at IGKVV, Raipur, Chhattisgarh on January 20-21, 2020.
- Dr A.K. Mall received Excellence Research Fellow Award-2020 from Association of Plant Science Researchers (APSR), Plantica Foundation, Dehradun on June 14, 2020.
- Dr Varucha Misra was awarded Young Scientist Award-2020 from Association of Plant Science Researchers (APSR), Plantica Foundation, Dehradun on June 14, 2020.

Best Ph.D. Thesis Award

- Dr Rajesh U Modi, Scientist was awarded International Best Ph.D.Thesis Award '*Giuseppe Pellizzi Prize* 2020' on research topic 'Design, development and evaluation of tractor operated seeder for mat type paddy nursery' from Club of Bologna, Italy and the Accademia deiGeorgofili sponsored by FEDERUNACOMA.
- Dr Varucha Misra was awarded Best Ph.D. Thesis Award 2018-19 in Frontier Sciences from Society for Agriculture and Allied Research, U.P. at JNU Convention Centre, New Delhi during January 31 - February 1, 2020.

Excellence Award by the Institute on the occasion of Foundation Day of ICAR-IISR, Lucknow on February 16, 2020.

- Best IISR Team Award was conferred to SWAPAM Lab of the Institute.
- Dr. A.K. Sah received IISR Best Scientist- 2019 Award.
- Dr. Lalan Sharma received IISR Best Young Scientist- 2019 Award.
- Mr. Brahm Prakash received The IISR Best Worker Award in Technical Category.
- Dr. Deepak Rai, Sh. C.P. Prajapati, Shri Abhay Kumar Srivastava, Shri Sant Ram and Shri

Rajendra Kumar received the Best Worker Awards in Technical Category.

- Sh. Awadhesh Kumar Verma and Shri Arvind Yadav received the IISR Best Worker Awards of Administrative Category.
- The Best Worker Awards for Skilled Supporting Staff was conferred to Smt. Shiv Devi Maurya.
- Dr Varucha Misra received Best Worker Award for outstanding contribution in Category-RA/SRF/JRF/YP.

Best Paper Award

- Dr. A.K. Mall received "Best Paper Award" for paper entitled "Sugar beet juice quality deterioration associated with increasing time duration after harvest" presented in International Conference on Advances and Innovations in Agriculture & Allied Sciences (AIAAS-2020) during January 31 - February 1, 2020.
- Dr. A.K. Mall received "Best Paper Award" for research paper "Periodic Occurrence of Sugar Beet Insect and Non-Insect Pests in India" presented in International Conference on Advances and Innovations in Agriculture & Allied Sciences (AIAAS-2020) during january 31 - February 1, 2020.
- Dr. Varucha Misra and Dr. A.K. Mall was conferred "Best Article Award" for paper entitled "Nano-Priming: An Emerging Technology for Quality Sugar beet Seed Production" published in Agriculture & Food: e-Newsletter 2(5) on May 5, 2020.

Best Poster Presentation Award

- Dr. A.K. Mall received "Best Poster Presentation Award" for presenting paper "Isolation and identification of endophytic bacteria from sugar beet root (*Beta vulgaris* L.) for enhancing ethanol production" under Natural Resource Management theme in International Conference on Advances and Innovations in Agriculture & Allied Sciences (AIAAS-2020) during January 31 - February 1, 2020.
- Dr. S.K. Holkar received "Best Poster Award" for the paper entitled "Screening of sugarcane genotypes against yellow leaf disease in tropical and sub-tropical conditions in India" presented during the 7th International Conference on Phytopathology in Achieving UN Sustainable Development Goals held at ICAR-IARI, New Delhi during January 16-20, 2020.

Examinership

- Dr. T.K. Srivastava worked as Thesis Examiner for Ph.D. (Agronomy) student of UAS, Dharwad and ANDUAT, Kumarganj, Ayodhya.
- Dr. P.K. Singh acted as Expert, Ph.D. and M.Sc. (Ag.) Thesis, *viva voce* and Dissertations of various Universities
- Dr. L.S. Gangwar acted as Examiner to evaluate answer copies and setting question paper of CSAUA&T, Kanpur.
- Dr. L.S. Gangwar acted as External Examiner to conduct *viva-vice* and Ph. D. Thesis evaluation at BHU, Varanasi and M.Sc. Thesis evaluation at GBPUA&T, Pantnagar.
- Dr. L.S. Gangwar acted as External Examiner for setting question paper and conducting practical exam at ICAR-IVRI, Izatnagar, Bareilly.
- Dr. Sanjeev Kumar (Biotechnology) served as External Examiner of *viva voce* of Ph.D. student at ANDUAT, Ayodhya on September 14, 2020.
- Dr. Sanjeev Kumar (Biotechnology) acted as External Examiner of *viva voce* of M.Sc. (Plant Biotech.) student at BHU, Varanasi.
- Dr. R.R.Verma worked as External Examiner for Ph.D. thesis evaluation and final thesis *viva voce* at CSAUA&T, Kanpur.
- Dr. S.R. Singh acted as External Examiner for Ph.D. Thesis evaluation of CSAUA&T, Kanpur.
- Dr. S.R. Singh acted as External Examiner for conducting Oral Comprehensive of Ph.D. student of CSAUA&T, Kanpur.
- Dr. Mona Nagargade worked as External Examiner to conduct the online practical examination of Weed Management for B.Sc. (Hons.) Agriculture III Year/VI Semester.

Editor

- Dr. Amaresh Chandra acted as Associate Editor of BMC Plant Biology (Section: Genetics and Crop Biotechnology), Associate Editor of Acta Physiolgiae Plantarum, Consulting Editor of SugarTech and Member Editorial Board J Sugarcane Research and J Agricultural Biochemistry
- Dr. Amaresh Chandra was appointed as Guest Editor of Annals of Microbiology. Special issue-7th International Conference on Agricultural and Biological Sciences.

- Dr. Sangeeta Srivastava served as Editorial Board Member of Indian Journal of Fundamental and Applied Life Sciences.
- Dr. Sangeeta Srivastava acted as Advisory Board Member of Agrica-An International Journal of Plant Science Researches.
- Dr. Sangeeta Srivastava served as Chief Editor, Indian Journal of Sugarcane Technology.
- Dr. Sangeeta Srivastava served as Editorial Board Member of Journal of Environmental Biology.
- Dr. Sangeeta Srivastava served as Consulting Editor of SugarTech
- Dr. M. Swapna Served in the Editorial Board of Sugar Tech.
- Dr A.K. Mall is Editorial Board Member in Plant Archives -An International Journal
- Dr A.K. Mall acted as Editor of Global Journal of Animal Science Livestock Production and Animal Breeding, Global Journal of Agriculture and Agricultural Sciences, Global Journal of Animal Breeding and Genetics, Agricultural Science Research Journal, Ghana (ARJ); Journal of Plant Science and Research, Scitech-The Journal of Science & Technology; Anveshan, Kisan P.G. College, Bahraich; Agriculture for Sustainable Development, Social and Farmers Welfare Society, BHU, Varanasi; Research in Environment and Life Sciences and Agriculture & Food: e-Newsletter magazine
- Dr Varucha Misra is Editor of Agriculture & Food: e-Newsletter magazine.

Reviewer

- Dr. T.K. Srivastava reviewed the research papers submitted to Indian Journal of Agricultural Sciences, Sugar Tech, Agriculture, Ecosystem and Environment (Elsevier publication) and Indian Journal of Sugarcane Technology.
- Dr. A.K. Jaiswal reviewed research manuscripts from 'Indian Journal of Entomology".
- Dr. Arun Baitha served as Reviewer for peer reviewed journals *i.e.* Journal of Plant Diseases and Protection, Sugar Tech, Indian Journal of Entomology and Florida Entomologist.
- Dr. Amaresh Chandra was Reviewer of research articles submitted to journals like Plant Cell Physiology, Sugar Tech, Acta Physiolgiae Plantarum, BMC Plant Biology, 3 Biotech, J Applied Microbiology *etc.*
- Dr. L.S. Gangwar seved as reviewer for peer reviewed journal Indian Journal of Agricultural Sciences.
- Dr. L.S. Gangwar reviewed a research paper submitted to Indian Journal of Sugarcane Technologist (IJST)
- Dr. Amaresh Chandra was invited and served as Reviewer of the National Academy of Agricultural Sciences (NAAS)-Policy paper
- Dr. Sanjeev Kumar served as Reviewer of international journals *viz.*, Journal of Plant Biochemistry and Biotechnology (Springer), Scientia Horticulturae (Elsevier), Physiology Molecular Biology of Plants (Springer), Sugar Tech (Springer), South African Journal of Botany and Indian Journal of Biotechnology.
- Dr. M. Swapna served as Reviewer for peer reviewed journals Physiology & Molecular Biology of Plants, Sugar Tech and Indian Journal of Sugarcane Technology.
- Dr. C.K. Gupta acted as Reviewer of Functional Plant Biology, Journal of Environmental Biology and Indian Journal of Agriculture Research.
- Dr. Radha Jain acted as Reviewer of research articles submitted to journals like Journal of Environmental Biology, Indian Journal of Sugarcane Technology, Indian Farming, Sugar Tech, Journal of Plant Nutrition and Soil Science.
- Dr A.K. Mall acted as Reviewer of PLOS One Journal, Journal of Environmental Biology, Journal of Agricultural and Crop Research (Scienceweb Publishing), International Journal of Agricultural Sciences, International Journal of Agriculture, Forestry & Fisheries, International Grass Congress-2015, Oryza, Indian Journal of Genetics & Plant Breeding, Indian Journal of Sugarcane Technology, Range Management and Agro-forestry, Journal of Plant Science and Research, Indian Journal of Plant Genetic Resources, SABRAO Journal of Breeding & Genetics, International Journal of Agriculture Sciences, Science International.

Member of RAC/IMC/QRT/IBSC

- Dr. Amaresh Chandra was Member of IMC of ICAR-SBI Coimbatore; ICAR-CISH Lucknow and ICAR-NIPB, New Delhi
- Dr. Amaresh Chandra was DBT approved internal expert of Institute Biosafety Committee ICAR-IISR, Lucknow for 3 years (2020 to 2023)

- Dr. Sanjeev Kumar (Biotech.) nominated as DBT Nominee 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.
- Dr. P.K. Singh acted as Expert Member for Research Advisory Committee of Autumn Season Research Programmes, GSBRI (UPCSR), Seorahi, Kushinagar.
- Dr. A.K. Singh was nominated as Member, Institute Management Committee of ICAR-IIOR, Hyderabad
- Dr. A.K. Singh was nominated by AKTU as Member, Board of Studies, Agricultural Engineering for another three years

Member of Assessment/Selection Committee

- Dr. A.D. Pathak was nominated by ASRB to act as Chairman, Assessment Committee of Technical Personnel (Field/Farm Technician) of ICAR-IIPR, Kanpur.
- Dr. Sangeeta Srivastava was nominated by ASRB to act as Member, Assessment Committee of Technical Personnel (Laboratory) of ICAR-IIPR, Kanpur on December 30, 2020.
- Dr. Sanjeev Kumar (Biotechnology) served as Expert Member in the Assessment Committee for Technical personnel of ICAR-IISR, Lucknow on August 28, 2020 and as ASRB Nominee at ICAR-IIVR, Varanasi on November 26, 2020.
- Dr. Sangeeta Srivastava served as Chairman and Expert Member in Selection Committees for SRF and YPs at ICAR-IISR, Lucknow.
- Dr. P.K. Singh acted as Expert Member for Selection Committees for Selection of SRF's, YPs' etc of ICAR-CISH, Lucknow on different dates.
- Dr. A.K. Sah was nominated as Expert Member in the Committee for Selection of Young Professional-II at ICAR-IISR, Lucknow on September 21, 2020.
- Dr. Sanjeev Kumar (Biotechnology) served as Expert Member for selection of YP at IISR, IISR, Lucknow on September 25-27, 2020; SRF at IISR, Lucknow on October 07, 2020, and at UPCSR, Shahjahanpur on October 12, 2020.
- Dr. A.K. Sah was nominated as Expert Member in the Committee for Selection of II JRF at ICAR-IISR, Lucknow on December 4, 2020.

Chairman/Co-Chairman/Rapporteur

- Dr. Sangeeta Srivastava was invited as the Chief guest and chaired the Inaugural Session of inter disciplinary e-workshop on Fundamental of Biotechnological Techniques (November 25 –December 1, 2020) organized by the CMP College, Prayagraj.
- Dr. Sangeeta Srivastava Chaired the Technical session- II of "International Conference on Advances and Innovations in Agriculture AIAAS-2020" held at JNU, New Delhi on February 01, 2020.
- Dr. Amaresh Chandra was Chairman of a Technical Session (Synthesis and Characterization of Nano-particles) in National Brainstorming Meet on Nanotechnology Applications in Sugarcane held at ICAR-IISR, Lucknow on January 10, 2020.
- Dr S.I. Anwar chaired a Technical Session on Sustainable Energy in National Conference on Sustainable Environment and Climate held at Sri Ram Swaroop Memorial University, Lucknow during January 07-09, 2020.
- Dr. S.I. Anwar co-chaired a Technical Session on Processing, Dairy and Food Engineering of 54th Annual Convention and International Symposium of Indian Society of Agricultural Engineering held at Pune during January 07-09, 2020.
- Dr. Amaresh Chandra acted as Rapporteur in 33rd Biennial Workshop of AICRP on Sugarcane held at ICAR- IISR, Lucknow.
- Drs. Sangeeta Srivastava and M. Swapna acted as Jury member for Best Research Paper Award of Journal of Sugarcane Research, SSRD, ICAR-SBI, Coimbatore in September 2020.

Organization of various events

- Dr. Amaresh Chandra organized NAAS Lucknow Chapter and Brainstorming Meet online on October 13, 2020 as Organizing Secretary.
- Dr. S.S. Hasan organized webinar on "Sugarcane Sector in Post COVID-19 and Way Forward" on 12th June, 2020 as Coordinator.
- Dr. Rajesh Kumar organized a Webinar on In-migrants livelihood in farm and sugarcane sector" on August 13, 2020 as Coordinator.
- Dr. L.S. Gangwar organized one day sensitization meeting on Intellectual Property, Technology Management and Entrepreneurship

Development as Coordinator and I/c, ITMU.

- Dr A.K. Mall was organizing Secretary of International Conference on Advances and Innovations in Agriculture & Allied Sciences (AIAAS-2020) held at JNU Convention Centre, New Delhi during January 31 - February 1, 2020.

Invited as key speaker in scientific meetings

- Dr. A.K. Sah was invited as Lead Speaker in a Webinar on "Entrepreneurship in Post COVID-19 for enhancing farmers' income" organized by Mewar University, Chittorgarh, Rajasthan on June 17, 2020.
- Dr. A.K. Sah was invited as Guest Speaker in Technical Session on "New Technologies, Sustainability and Innovations in Growing Cane" in India International Food and Agri Week -2020 organized by CII on October 16-22, 2020.
- Dr. A.K. Sah was invited as Guest speaker in *Hindi Karyashala* in CSIR- CIMAP, Lucknow on December 22, 2020.
- Dr. A.K. Sah was invited as Sugarcane Expert by Hasanpur Sugar Mill, Hasanpur (Bihar).
- Dr. A.K. Sah was invited as Guest speaker in Online training programme on Sustainable Sugarcane Initiative organized by ITC Sunehra Kal on November 12, 2020.
- Dr. A.K. Sah was invited as Guest Speaker in Online Leadership Development Programme for Sugar Cooperatives in India organized by National Centre for Cooperative Education, New Delhi on October 12-14, 2020.
- Dr. L.S. Gangwar delivered lectures in the short-term training courses conducted by Institute from time to time.
- Dr Sukhbir Singh delivered a lecture in International Training on "Present and futuristic trends in Agricultural Mechanization" during June 18-23, 2020 organized by VNMKV, Parbhani (Maharashtra).

Others

- Dr. Sangeeta Srivastava served as Nodal Officer-SFC/EFC (2020-25) of Commercial Crops of ICAR, New Delhi.
- Dr. Amaresh Chandra was Member of a Committee for Screening and evaluation of projects submitted to SERB (DST), Govt. of India.
- Dr. T.K. Srivastava, worked as Principal Investigator (Crop Production) AICRP on Sugarcane and Member, National Monitoring Team constituted by AICRP on Sugarcane.
- Dr. T.K. Srivastava, worked as Member Expert Panel of UPCAR for evaluation of research work done under projects funded by the organization all across the state of Uttar Pradesh.
- Dr. T.K. Srivastava, worked as Member, Varietal Identification Committee of the AICRP on sugarcane.
- Dr. T.K. Srivastava, worked as Expert Member for training of Master Trainers under Million Farmers' School Campaign of Department of Agriculture, Govt. of U.P.
- Dr. S.I. Anwar acted as Member, Project Monitoring Committee of Ministry of Environment, Forest and Climate Change, Govt. of India.
- Dr. S.I. Anwar acted as Secretary of Lucknow Chapter of Indian Society of Agricultural Engineers (ISAE).
- Dr. Amaresh Chandra was appointed as Member Technical Programme Committee of 6th International Conference on Agricultural and Biological Sciences (ABS 2020) held in Tokyo, Japan.
- Dr. Pushpa Singh chaired Session II Sugarcane sugar and ethanol, - An interactive session with stakeholders on October 19-20, 2020.
- Dr. Sanjeev Kumar (Biotechnology) was conferred Elected Membership of Plant Tissue Culture Association-India (PTCA-I).
- Dr. A.K. Sah was nominated in Committee constituted by Sugarcane and Sugar Industry, Govt. of Uttar Pradesh for Promoting Tourism in Sugar Industry in U.P.
- Dr. A.K. Sah was nominated as Nodal Officer to support capacity building and training of stakeholders under PMFME scheme in sugarcane in the identified district of Uttar Pradesh.

***Mithaas* Trophy Awarded to Crop Improvement Division by the Institute**

CHAPTER 16

Publications

Research Papers published in National / International Journals

Baitha Arun, Jaiswal AK, Kumar A and Kumar Anuj. 2020. Observations on protective silken disc numbers in pupal chamber sugarcane top shoot borer, *Scirpophaga excerptalis* (Walker) (Crambidae: Lepidoptera). *Hexapoda (Insectaindica)* **25**(1&2):1-4.

Baitha Arun, Srivastava DC and Singh MR. 2020. A Note on *Telenomusdignus* (Gahan) (Scelionidae: Hymenoptera): on eggs of sugarcane internode borer, *Chilo sacchariphagus indicus* (Kapur). *Hexapoda (Insectaindica)* **24**(1&2):16-20.

Baitha Arun, Sushil SN, Kumar A, Kumar Anuj and Maurya BL. 2020. Superparasitism in natural population of *Trichogramma chilonis* Ishii (Trichogrammatidae: Hymenoptera) on eggs of sugarcane internode borer. *Hexapoda (Insectaindica)* **25** (1&2):5-11.

Banerjee N, Khan MS, Swapna M, Singh RK and Kumar S. 2020. Progress and prospects of association mapping in sugarcane (*Saccharum* species hybrid), a complex polyploid crop. *Sugar Tech.* **22**(6): 939-953.

Borase DN, Nath CP, Hazara KK, Senthilkumar M, Singh SS, Praharaj CS, Singh U and Kumar N. 2020. Long-term effect of diversified crop rotation and nutrient management practices on soil microbial function and soil enzymes activity. *Ecological Indicators*, doi.org/10.1016/j.ecolind. 2020.106322.

Borase DN, Senthilkumar M, Nath CP, Hazara KK, Singh SS, Singh U, Kumar N and Praharaj CS. 2020. Long-term impact of grain legumes and nutrient management practices on soil microbial activity and microbial properties. *Archives of Agronomy and Soil Science* doi.org/10.1080/ 03650340.2020.1819532

Chaudhari SS, Sudhishri S, Khanna M, Dass A, Rosin KG, Blessy VA and Singh P. 2020. Operational guidelines for enhancing irrigation system efficiency in tubewell command. *Journal of Soil and Water Conservation* **19**(1): 83-90.

Dash BS, Kumar A, Modi Rajesh U and Kumar SN. 2020. Design and performance evaluation of self-propelled intra-canopy boom spraying system. *Journal of Agricultural Engineering* **57**(3): 195-209.

Duttamajumder SK and Singh MR. 2020. Another white fly infesting sugarcane in India. *Indian Journal of Sugarcane Technology* **35** (01):64-66.

Goswami SK, Singh D, Joshi D and Singh SP. 2020. An insight into sugarcane wilt in India. *Agric Res J* **57**(5): 641-647.

Goswami SK, Kashyap PL and Awasthi S. 2020. Deciphering rhizosphere microbiome for the development of novel bacterial consortium and its evaluation for salt stress management in solanaceous crops in India. *Indian Phytopathology*, 72(3): 479-488.

Goswami SK, Singh V, Kashyap PL and Singh PK. 2020. Morphological characterization and screening for sheath blight resistance using Indian isolates of *Rhizoctonia solani* AG1IA. *Indian Phytopathology*, **72**(1): 107-124.

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

Gujjar RS, Banyen P, Chuekong W, Worakan P, Roytrakul S, and Supaibulwatana K, 2020, A synthetic cytokinin improves photosynthesis in rice under drought stress by moduiating the abundance of proteins related to stomatal conductance, chlorophyll contents, and rubisco activity. *Plants*, 9(9):1106.

Hasan SS and Kumar Sanjeev. 2020. Internet of Things (IoT) applications-advantages for sugarcane farming. *Indian Journal of Sugarcane Technology* **35**(01): 1-4.

Hasan SS, Pathak AD, Shukla SK, Gangwar LS and Kumar Rajesh. 2020. Web-based data management techniques for coordinated trials of sugarcane technologies, *Sugar Tech*, **22**(6): 1158-1165.

Hasan SS, A D Pathak, S K Shukla and Rajesh Kumar. 2020. AICRP Reporter: A web-based reporting system for the trials of AICRP on Sugarcane. *Indian Journal of Sugarcane Technology* **34** (02):51-52.

Holkar SK, Balasubramaniam P, KumarA, Kadirvel N, Shingote PR, Chhabra ML, Kumar S, Kumar P, Viswanathan R, Jain RK and Pathak AD. 2020. Present status and future management strategies for sugarcane yellow leaf virus: A major constraint to the global sugarcane production. *Plant Pathology Journal* **36**(6) : 536-557.

Jadhao S, Manimaran B, Thorat YE, Jain PK and Sirohi A. 2020. *In Silico* analysis of *ema*-I gene of southern root-knot nematode. *Meloidogyne incognita*. *Indian Journal of Nematology* **49** : 173-178.

Jain R. and Gupta A. 2020. Ethephon alters sugarcane growth, biochemical attributes and SOD and ETR gene pattern under drought stress. *Advances in Bioresearch* **1**(5/6):

Jain Radha. 2020. Sugarcane bud chip technology and its mechanization. *World Journal of Agricultural Sciences* **16** (5): 312-317.

Jain Radha, Gupta A, Chandra A and PathakAD. 2020. Morphological alterations and gene expression in a set of sugarcane varieties under waterlogged conditions. *Plant Cell Biotechnology and Molecular Biology* **21**(59 & 60): 84-91.

Jaiswal VP, Shukla SK, Sharma Lalan, Singh Ishwar, Pathak AD, Nagargade Mona, Ghosh Arup, Gupta C, Guar Asha, Awasthi SK, Tiwari Raghavendra, Srivastava Abhay and Masto Ebhin. 2020. Potassium influencing physiological parameters, photosynthesis and sugarcane yield in sub-tropical India. *Sugar Tech*. https://doi.org/10.1007/s/12355-020-00905-z.

Jaiswal AK and Singh JP. 2020. Response of novel insecticides in enhancing the productivity of lac on *Flemingia semialata*. *Indian Journal of Agricultural Sciences*, **90**(4):689-92.

Joshi D, Singh P, Holkar S and Kumar S. 2019. *Trichoderma* mediated suppression of red rot of sugarcane under field conditions in sub-tropical India. *Sugar Tech*. **21**(3): 496-504.

Kapur R, Kumar S, Singh J, Singh PK, Swapna M, Pandey DK, Kumar D, Kumar S, Srivastava TK, Singh D and Pathak AD. 2020. Variety notification- sugarcane variety 'CoLk 12209' (*Ikshu -7*). *Indian Journal of Genetics & Plant Breeding* **80**(1):119-120.

Kumar A, Holkar SK and Singh R. 2020. Natural occurrence and diagnosis of yellow leaf disease affecting sugarcane genotypes under tropical and sub-tropical conditions in India. *Journal of Environmental Biology*. **41**(6): 1511-1520.

Kumar P, Chauhan VS and Srivastava S. 2020. Diversity analysis of kinase like disease resistance gene analogues in sugarcane. *Archives of Phytopathology and Plant Protection*, https://doi.org/10.1080/03235408.2020.182944.

Kumar P, Chauhan VS and Srivastava S. 2020. Omics approach for stress tolerance in crop plants. *Plant Archives* **20** (Special issue): 261-266.

Kumar N, Singh SS, Ghosh PK, Hazra KK, Venkatesh MS, Praharaj, CS, Singh MK, Senthil KM, Basu PS, Yadav A, Yadav SL, Singh S, Singh NP. 2020. Improving chickpea productivity in rice-fallow of Indo-Gangetic plain with soil moisture conservation and cultivar selection. *Journal of Food Legumes* **33**(1): 28-35.

Kumar Rajesh. Pathak AD and Bakshi Ram. 2020. Climate resilient, high yielding and stable sugarcane genotypes in India. *Journal of Indian Society of Agricultural Statistics*, **74**(1): 11–16.

Kumar Anuj, Baitha Arun and Kumar A. 2021. Response of pupal weight of stalk borer, *Chiloauricilius* Dudgeon (Crambidae: Lepidoptera) on biology of *Tetrastichus howardi* (Olliff) (Hymenoptera: Eulophidae). *Insect Environment*, **24:** 74-76.

Kumari Namrata, Datta Jhuma, Kumar Rajeev, Chakravarty A and Pal Srikumar. 2020. Herbicide induced changes in nutrient and antinutrient content during mungbean (*Vigna radiata* L.) seed development. *International Journal of Chemical Studies* **8**(2): 223-228.

Kumari Namrata, Datta Jhuma, Kumar Rajeev, Chakravarty A and Pal Srikumar. 2020. Effect of quizalofop and fenoxaprop on nutrient and antinutrient contents during seed development of mungbean (*Vigna radiata* L.). *Journal of Pharmacognosy and Phytochemistry* **9**(2): 664-669.

Kumar Sanjeev, Singh J, Singh PK, Pandey DK, Kumar Devendra, Singh Dinesh, Srivastava TK, Singh RK, Kumar Sanjeev and Pathak AD. 2020. CoLk 12207 (*Ikshu-6*) : An early maturing sugarcane variety for North Central and North East Zone. *Indian Journal of Sugarcane Technology* **35** (1): 45-49.

Kumar S., Singh J, Singh PK, Pandey DK, Kumar D, Singh D, Srivastava TK, Singh RK, Kumar S and Pathak AD. 2020. Sugarcane variety 'CoLk 12207' (*Ikshu-6*). *Indian Journal of Genetics and Plant Breeding* **80**(1): 118-119.

Mahajan GR, Das B, Manivannan S, Manjunath BL, Verma RR, Desai S, Kulkarni RM, Latare AM, Sale

R, Murgaonkar D, Patel KP, Morajkar S, Desai A, Barnes N, Mulla H. 2020. Soil and water conservation measures improve soil carbon sequestration and soil quality under cashews. *International Journal of Sediment Research*. DOI: 10.1016/j.ijsrc.2020.07.009

Misra V, Mall AK, Kumar M, Srivastava S and Pathak AD. 2020. Identification of two new *Alternaria* isolates on sugar beet (*Beta vulgaris* L.) plants in Lucknow, India. *Archives of Phytopathology and Plant Protection*, DOI: 10.1080/03235408.2020.1824378.

Misra V, Solomon S, Hasan A, Allah EFE, Al-Arjani AF, Prajapati CP, Mall AK and Ansari, MI. 2020. Minimization of post-harvest sucrose losses in drought affected sugarcanes using chemical formulation. *Saudi Journal of Biological Sciences* **27**(1): 309-317.

Misra V, Solomon S, Hassan A, Allah EFE, Al-Arjani AF, Mall AK, Prajapati CP and Ansari MI. 2020. Morphological assessment of water stressed sugarcane : A comparison of drought and water logging canes. *Saudi Journal of Biological Sciences*, **27** (5) : 1228-1236.

Misra V, Solomon S, Mall AK, Prajapati CP and Ansari MI. 2020. Impact of chemical treatments on *Leuconostoc* bacteria from harvested stored/stale cane. *Biotechnology Reports* **27** : e005.

Santeshwari, Misra V, Mall AK and Kumar D. 2020. Problems and integrated pest management strategy for *Spodoptera litura* in Sugar beet in India. *J. Exp. Zool. India*, **33**(2): 1887-1890

Sharma AK, Pathak AD, Kumar Rajesh, Singh AK and Brahm Prakash. 2020. Pattern and trend in casualization of agricultural labour absorption in sugarcane cultivation in India: An analysis across states agro-climatic zones and farm sizes. *Indian Journal of Agricultural Economics* **75**(4):538-539.

Sharma D, Nanjundan J, Singh L, Singh SP, Parmar N, Sujith Kumar MS, Singh KH, Mishra AK, Singh R, Verma KS, Thakur AK. 2020. Genetic diversity in leafy mustard (*Brassica juncea* var. rugosa) as revealed by agro-morphological traits and SSR markers. *Physiology and Molecular Biology of Plants* **26**(10): 2005–2018.

Shukla SK, Jaiswal VP, Sharma Lalan, Pathak AD, Awasthi SK, Gaur Asha and Tiwari Raghvendra. 2020. Zinc and sulphur nutrition in sugarcane *(Sachharum officinarum)* and potato *(Solanum tuberosum)* intercropping system affecting soil microbial biomass carbon, respiration and crop growth in sub tropical India. *Indian Journal of Agronomy* **65**(1): 33-40.

Shukla SK, Jaiswal VP., Sharma Lalan, Pathak AD, Singh Akhilesh Kumar, Gupta R, Awasthi SK, Gaur Asha, Zubair Adil and Tiwari Raghavendra. 2020. Sugarcane yield using minimum tillage technology through sub-soiling: Beneficial impact on soil compaction, carbon conservation and activity of soil enzymes. *Sugar Tech*. **22**: 987-1006.

Shukla SK, Sharma Lalan, Jaiswal VP, Pathak AD, Awasthi SK, Zubair Adil and Yadav SK. 2020. Identification of appropriate Agri-technologies minimizing yield gaps in different sugarcane growing states of India. *Sugar Tech*.(https://doi.org/10.1007/s/12355-020-00907-x).

Shukla SK, Sharma Lalan, Jaiswal VP, Pathak AD, Tiwari Raghvendra, Awasthi SK and Gaur Asha. 2020. Soil quality parameters *viz-a-viz* growth and yield attributes of sugarcane as influenced by integration of microbial consortium with NPK fertilizers. *Scientific Reports*, Springer Nature Limited. doi: published by www.nature.com/scientificreports.https://doi.org/10.1038/s41598-020-75829-5.

Shukla SK, Swahashee, Maity SK, Awasthi SK and Gaur Asha. 2020. Growth, nutrient accumulation and crop yields as influenced by crop residues recycling and *Trichoderma* inoculation in rice *(Oryza sativa)* – wheat *(Triticum aestivum)* and sugarcane- ratoon-wheat cropping systems in sub tropical India. *Indian Journal of Agronomy*. **65**(1): 1-9.

Singh MK, Singh SP, Kushwaha HL, Singh Mukesh K and Ekka U. 2020. Combine harvester: Opportunities and prospects as resource conservation technology. *RASSA Journal of Science for Society* **2**(1): 53-57.

Singh R, Vandana P, Pallavi, Singh MR, Kumar S, Singh PK. Singh J and Singh D. 2020. Evaluation of new sources of resistance and variability for sugarcane smut disease. *International Journal of Current Microbiology and Applied Sciences* **9**(10): 3205-3215.

Singh RK, Sharma, AK, Singh YP and Tripathi, SC. 2020. Dairy sector development in sugarcane-based cropping system of Uttar Pradesh: Challenges and opportunities. *Journal of Community Mobilization and Sustainable Development* **15**(1): 17-31.

Singh SN, Sah AK, Patnaik JR, Singh RK. and Singh VK. 2020. On-farm trial on inter and sequential crops with sugarcane for assessing yield and economic returns of the system in sub-tropical India. *Indian Journal of Extension Education*, **56**(1): 238-240.

Singh S, Pushpavathi B, Madhavan S. and Sharma R. 2020. Expression of defense-related enzymes in blast [*Magnaporthe grisea* (Herbert) Barr] resistant and susceptible genotypes of pearl millet [*Pennisetum glaucum* (L.) R. Br.]. *Archives of Phytopathology and Plant Protection*, pp.1-23.

Singh SR, Yadav P, Singh D, Tripathi MK, Bahadur L, Singh SP, Mishra A and Kumar S. 2020. Cropping systems influence microbial diversity, soil quality and crop yields in Indo-Gangetic plains of India. *European Journal of Agronomy*, **121:** 126-152.

Singh SR, Yadav P, Singh D, Lal B, Singh SP, Yadav AK, Mishra A, Yadav PPS and Kumar S. 2020. Impact of different crop grown system on microbial diversity, soil quality and nutrient index. *Land Degradation and Development*. https://dox.doi.10.1002/ldr.3863.

Solomon S, Rao GP and Swapna M. 2020. Impact of COVID 19 on Indian Sugar Industry. *Sugar Tech*. **22**(4):547-551.

Sushil SN, Chandra A, Roy S. Jaiswal AK, Singh MR and Pathak AD. 2020. Determination of morphological and biochemical basis of resistance against top borer, *Scirpophaga excerptalis* Walker in sugarcane. *Sugar Tech* **22**: 259–265.

Sushil SN, Kalleshwaraswamy CM, Ranjith M, Roy S, Jaiswal AK, Joshi D and Pathak AD. 2020. Incidence and diversity of termites associated with sugarcane in North-west zone of India with new records. *Sugar Tech*, 22:1-8.

Sushil SN, Roy S, Jaiswal AK, Joshi D and Pathak AD. 2020. Management of termites through different tools and their impact on environment and soil micro-arthropods in sugarcane in Indo-Gangetic plains of India. *Sugar Tech*, DOI: 10.1007/s 12355-020-00938-4.

Swapna M, Kapur R and Pandey DK. 2020. Recurrent selection cycles for pre-breeding in sugarcane: enhancing the sugar-accumulation potential in selection cycles. *International Sugar Journal* **122**(1459): 496-502.

Swapna M, Kapur R, Kumar S, Kumar D, Singh J, Singh PK, Pandey DK, Kumar S, Srivastava TK, Singh D and Pathak AD. 2020. 'CoLk 12209' (*Ikshu-7*) - a new mid-late maturing sugarcane variety for North Central and North East zone of sub-tropical India. *Journal of Sugarcane Research* **10**: 43-53.

Vandana P, Singh Dinesh, Srivastava S and Guru GR. 2020. Effect of climate change on sugarcane crop: A review. *Journal of Pharmacognosy and Phytochemistry SP* 6: 255-261.

Verma I, Chandra A and Kamal A. 2020. Identification and validation of differentially expressing transcripts from top and bottom internodes of high-sucrose sugarcane variety CoJ 64. *SugarTech* **22**:89-97.

Yadav SK, Singh RK, Singh SK, Yadav S and Bakade RR. 2020. Site specific nutrient management in potato through nutrient omission plot technique. *Journal of Agri Search* 7(2): 59-62.

Yadav SK, Singh RK, Dua VK, Singh SK, Yadav S and Bakade RR. 2020. Nitrogen requirement of potato for Eastern Indo-Gangetic Plain of India. *Journal of Agri Search* 7(3):134-137.

Books/Reports/Souvenir/Periodicals:

Jain Radha, Pathak AD, Solomon S, Chandra A, Brahm Prakash and Singh CP. 2020. Ethephon: *Ganne Ki Karyiki Evam ChiniUtpadakta Par Prabhav* (Hindi), ICAR-IISR, Lucknow, 111p.

Kumar Rajesh. 2020. Souvenir of National Seminar on "Biofuel Production in India: Potential, Prospect and Technology" conducted by North Indian Sugarcane and Sugar Technologists' Association (NISSTA) and CSIR- Indian Institute of Petroleum, Dehradun (UK) held on February 21, 2020.

Mall AK, Misra V., Singh R.K., Sharma T. and Santeshwari. 2020. Souvenir cum Abstract Book. International Conference on Advances and Innovations & Allied Sciences (AIAAS-2020) held during 31st January-1st February, 2020. 197 p.

Roychowdhury R., Choudhury S., Hasanuzzaman M. and Srivastava Sangeeta (Eds.). 2020. *Sustainable Agriculture in the Era of Climate Change*. Springer Nature Switzerland AG. ISBN 978-3-030-45668-9 https://doi.org/10.1007/978-3-030-45669-6690 p.

Sah AK, Singh VK, Brahm Prakash and Singh Abhishek Kumar. 2020, *Ikshu Rajbhasha Patrika* 9(1): January-June, 2020, ICAR-IISR, Lucknow. 126 p.

Sah AK, Singh VK, Brahm Prakash and Singh

Abhishek Kumar. 2020, *Ikshu Rajbhasha Patrika* 9(2): July-December, 2020, ICAR-IISR, Lucknow. 112 p.

Singh Sukhbir, Singh AK and Pathak AD. (Eds.). 2020. Improved Sugarcane Mechanization Technologies. ICAR-Lucknow, India. 177p.

Srivastava S., Gangwar LS, Sharma AK and Prakash Brahm. 2020. Annual Report (2019). ICAR-IISR, Lucknow. 145 p.

Srivastava S, Gangwar LS, Prakash Brahm and Sawnani A. 2020. *Varshik Prativedan (Hindi)* (2018-19). ICAR-IISR, Lucknow. 149 p.

Papers presented in Seminars/Symposia/ Conferences etc.

107th Indian Science Congress held at University of Agricultural Sciences, Bengaluru during January 03-07, 2020

Anwar SI and Sahu T. 2020. Cleaner-cum-washer: A utility machine for sugarcane juice and jaggery. p.178.

54th Annual Convention of ISAE and International Symposium on "Artificial Intelligence Based Future Technologies in Agriculture" held at Hyatt Regency, Pune during January 7-9, 2020

Anwar SI, Singh RD and Singh P. 2020. Protein enrichment of jaggery through natural source.

Gupta Rajendra and Singh AK. 2020. Economising use of land and water resources for sugarcane production through potato intercropping.

Singh Sukhbir and Singh AK. 2020. Drudgery reducing improved manual tools and equipment for sugarcane cultivation.

National Symposium on Plant Disease Management for Food Security under Climate Change Scenario and Annual Meeting of Indian Phytopathological Society (North Zone)" at ICAR-Indian Institute of Wheat and Barley Research (IIWBR), Karnal during January 9-10, 2020

Goswami SK and Srivastava AK. 2020. Insight into *Ustilaginoidea virens* causing false smut of rice in India. p. 55

7th International Conference on "Phytopathology in Achieving UN Sustainable development goals,16-20, Jan, 2020 at ICAR-IARI, New Delhi

Goswami SK, Chakdar H, Verma S, Tiwari P, Shahid M, Singh BN, Das S, Kumar M and Srivastava AK. 2020. Characterization of *Villosiclava virens* causing false smut of rice and its bio-control in India., pp.106-107.

2nd International Conference & Exhibition on Sustainability-Innovation & Diversification in Sugar and Allied Industry held at Vasantdada Sugar Institute, Pune during January 31 -February 2, 2020

Brahm Prakash, Gangwar LS, Sharma AK, Om Prakash, Singh Kamini and Pathak AD. 2020. Global sugar scenario in respect to production, consumption and trade. p: 17.

Gangwar LS, Pathak AD, Hasan SS, Brahm Prakash and Singh Kamini. 2020. Diversification of sugar and bio-ethanol production for sustainable development in India: An economic analysis. p: 142.

Kumar, A, Holkar SK and Singh R. 2020. Detetion of phytoplasma in yellow leaf disease effect on sugarcane genotypes evaluated in tropical condition in India. p. 25.

Om Prakash, Brahm Prakash, Sah AK, Pathak AD and Yadav Pallavi. 2020. Sustainable soil health management in sugarcane for climate smart agriculture. ASP. 10.

Sah AK and Pathak AD. 2020. Public-Private-Farmer Partnership to make cane farmer viable, ASP. 09.

Singh Kamini, Gangwar LS, Brahm Prakash and Pathak AD. 2020. Prospects and challenges of Indian sugar sector under emerging global scenario. p. 18.

Swapna M. and Solomon S. 2020. Green technologies in sugarcane agriculture: Mitigating climate change. p.115.

Swapna M., Kumar Sanjeev, Kapur R and Pandey DK. 2020. Identifying high sugar parental stocks of sugarcane through recurrent selection. p. 114.

Thorat YE. Kumar A. Borase DN, Holkar SK, Sushil SN and Pathak AD. 2020. Use of IISR-combo insect trap for the management of white grubs in sugarcane. ASP-64.

International Conference on Advances and Innovations in Agriculture & Allied Sciences (AIAAS-2020) held at Jawaharlal Nehru University, New Delhi on January 31-February 1, 2020

Malaviya A, Malaviya N, Singh BD, Misra V and Mall AK, 2020. Status and impact of sugarcane breeder seed production in Bihar. p. 158.

Misra V, Mall AK, Santeshwari, Kumar D and Pathak AD. 2020. Sugar beet juice quality deterioration associated with increasing time duration after harvest. p. 37.

Prakash Om, Brahm Prakash, Yadav Pallavi, Sah AK, Singh Kamini and Pathak AD. 2020. Different

approaches of fertilizer recommendation for sustainable soil health and its productivity for food and environmental security of India. p. 95.

Santeshwari, Malaviya A, Misra V, Singh BD and Mall AK. 2020. Periodic occurrence of sugar beet insect and non-insect pests in India. p. 46.

Srivastava S, Pathak AD, Mall AK, Santeshwari, Misra V and Singh R. 2020. Isolation and identification of endophytic bacteria from sugarbeet (*Beta vulgaris*) roots for enhancing ethanol production. p. 151.

Srivastava Sangeeta. 2020. MicroRNA guided regulation of gene expression *vis-à-vis* adaptation of sugarcane for stress tolerance. p. 18.

Vandana Priyam, Singh D, Srivastava Sangeeta and Ram GD. 2020. Studies on management of red rot disease through rhizospheric mycoflora of sugarcane. p. 150.

Yadav Pallavi, Prakash Om, Brahm Prakash and Singh Kamini. 2020. Digital approaches for soil testing: Helpful tool for sustainable soil health management and agricultural development. p. 67.

National Conference on Sustainable Environment and Climate (SOLARIS-2020) at SRMU, Barabanki during February 7-9, 2020

Anwar SI. 2020. Energy conservation in sugarcane processing for jaggery making.

Gupta Rajendra and Singh PR. 2020. Design and development of culti-harrow – A time, energy and cost saving land preparation implement for sugarcane farming.

Singh MK, Singh SP, Singh Mukesh K and Singh RD. 2020. Development of a battery-assisted four-wheel weeder for multi-operation to increase productivity with reduced drudgery.

Singh Sukhbir and Singh AK. 2020. Solar-powered manual sprayer – A promising RE technology.

Integrated Workshop on Publication Ethics and Patenting and International Conference on Environmental Sustainability: Innovations, Translational Dimensions and Way Forward held at Baba Saheb Bhimrao Ambedkar University, Lucknow during February 10-12, 2020

Prakash Om, Brahm Prakash, Yadav Pallavi, Sah AK and Pathak AD. 2020. Soil testing tools: An urgent need of the hour for the soil health, sustainable crop production and environmental security. pp. 79-80.

Singh Kamini, Gangwar LS, Brahm Prakash, Om Prakash and Pathak AD. 2020. Farmers' rights in India in present IP regime. p. 50.

Yadav Pallavi, Om Prakash, Brahm Prakash, Sah AK, Pathak AD. and Singh Jiwan. 2020. Integrated nutrient management for sustainable sugarcane production, soil health and environmental security. pp. 76-77.

International Conference on Pulses as the Climate Smart Crops: Challenges and Opportunities (ICPulse 2020) held at Bhopal on February 10-12, 2020

Das Krishnashis, Borase DN and Kumar Senthil. 2020. Interactive effect of lentil genotypes-rhizobia on biological nitrogen fixation.

Prakash, Om, Prakash Brahm, Sah AK, Pathak AD and Yadav Pallavi. 2020. Intercropping of short duration pulses in sugarcane for increasing pulses production and farmers' income. p. 261.

Singh, Kamini, Brahm Prakash, Sawnani Anita, Sharma AK and Om Prakash. 2020. Global trends in production, consumption and trade of pulses.

Singh MK, Singh AK and Singh Sukhbir. 2020. Mechanization of sowing of pulses as companion crop along with sugarcane planting.

Sharma AK, Brahm Prakash and Pathak AD. 2020. Productivity and profitability changing scenario in chickpea and lentil cultivation in major sugarcane producing state of Uttar Pradesh.

9th National Seminar on Doubling Farmers Income by 2022: Challenges, Opportunities and Way Forward held at Career Point University, Bhoranj, Hamirpur (Himachal Pradesh) on February 15-17, 2020

Sah AK and Pathak AD. 2020. Extension strategy for doubling farmers' income amidst changing climate scenario.

Sharma AK, Rajesh Kumar and Pathak AD. 2020. Rainfall variability and prospects of sugarcane cultivation for quality jaggery production in Himachal Pradesh.

ISPP North Zonal Seminar-2020 on Crop Productivity and Stress Management held at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur on February 22, 2020

Prakash Om, Brahm Prakash, Yadav Pallavi, Sah AK and Singh Kamini. 2020. Management options for alleviating drought tolerance in chickpea. pp. 45-46.

5th Uttar Pradesh Agricultural Science Congress on Enhancing Farmers Income and Water Conservation: Opportunities and Challenges held at Banaras Hindu University, Varanasi on February 22-24, 2020

Brahm Prakash, Sharma AK, Gangwar LS, Sawnani Anita, Om Prakash and Pathak AD. 2020. Immense agribusiness potential of jaggery in Uttar Pradesh. p. 320.

Mohd. Ashfaque, Brahm Prakash, Sharma AK, Om Prakash and Singh Kamini. 2020. Bright prospects of agribusiness of mentha oil in Uttar Pradesh. p. 321.

Om Prakash, Brahm Prakash, Sah AK, Yadav Pallavi and Pathak AD. 2020. Improving water use efficiency for sugarcane cultivation under sub-tropical conditions. p. 103.

Om Prakash, Brahm Prakash, Sah AK, Yadav, Pallavi and Pathak AD. 2020. Efficient water management techniques in sugarcane production under sub-tropical conditions. p.102.

Singh Kamini, Gangwar LS., Brahm Prakash and Pathak AD. 2020. Emerging scope of intellectual property rights in agriculture. p. 173.

Srivastava Sangeeta and Pathak AD. 2020. Role of chromosome number variation *vis-a vis* species-specific chromosomes in adaptability of sugarcane genotypes to subtropical India. pp. 168-169.

National Webcon held at C.S. Azad University of Agriculture & Technology, Kanpur on May 6-8, 2020

Misra V, Mall AK, Santeshwari and Pathak AD. 2020. Problems and strategies adopted for assessment of drought stress in sugarbeet under COVID 19 pandemic situation.

National Webinar on "Covid 19 and Agriculture" organized by Chandra Bhanu Gupt PG Agriculture College, Lucknow on June 25, 2020

Prasad Kamta, Lal B, Verma RR and. Dohare RS. 2020. Impact of COVID -19 on Agriculture.

National Web-Conference on Technological Approaches for Resource Conservation and Management for Environmental Sustainability organized by Academy of Natural Resource Conservation and Management (ANRCM), Lucknow on August 16-17, 2020

Blessy VA and Chaudhari Shiv Shanker. 2020. Application of modern tools in agricultural water management. p. 81.

Chaudhari Shiv Shanker and Blessy VA. 2020. Dynamics of drip irrigation to enhance crop water productivity. p. 80.

International Plant Pathology Congress (IPPC-2019) entitled "Crop Protection to Outsmart Climate Change in Food Security and Environmental Conservation" held at ICRISAT, Hyderabad on November 10-14, 2020

Goswami SK, Srivastava AK and Kashyap AS. 2020. Investigations on *Ustilaginoidea virens* causing false smut of rice in India. p.191.

Book Chapters/Souvenir-cum Abstract Book

Book Chapters published in Improved Sugarcane Mechanization Technologies (Eds: Sukhbir Singh, AK Singh and AD Pathak), ICAR-IISR, Lucknow, ISBN: 978-93-5396-574-7, 177p.

Anwar SI. 2020. Processing technologies for jaggery manufacturing. pp. 157-161.

Gupta Rajendra. 2020. Micro-irrigation system for water management in sugarcane. pp. 76-85.

Jain Radha. 2020. Potential of sugarcane bud chip technology and its mechanization. pp, 55-62.

Kumar Dilip. 2020. Packaging and storage of jaggery. pp. 172-177.

Kumar Rajesh. 2020. Overview of sugarcane and sugar in the world. pp. 5-13.

Kumar Sanjeev. 2020. Promising sugarcane varieties and their suitability for mechanization. pp. 31-38.

Pathak AD. 2020. Sugarcane mechanization research at IISR. pp. 1-4.

Sah AK. 2020. Entrepreneurship development in sugarcane for enhancing farmers' income. pp. 147-156.

Sharma AK. 2020. Economics of improved sugarcane machinery use in India. pp.130-139.

Shukla SK, Sharma Lalan and Jaiswal VP. 2020. Management of sugarcane ratoon for improving crop growth and yield. pp. 111-118.

Singh Dinesh. 2020. Moist hot air treatment and its impact on disease management. pp. 86-92.

Singh J. 2020. Processing of sugarcane to produce value added products for increasing farmers' income. pp. 162-165.

Singh MK and Singh AK. 2020. Trash management machines for sugarcane. pp.125-129.

Singh MR.2020. Insect pests of sugarcane and tools

used for their management. pp. 93-104.

Singh AK and Singh Sukhbir. 2020. Recent development in mechanization of sugarcane planting and intercropping machines. pp. 50-54.

Singh AK and Singh Sukhbir. 2020. Recent development in sugarcane harvesting machinery. pp. 105-110.

Singh AK, Singh RD and Singh Sukhbir. 2020. Mechanization of sugarcane ratoon management operations. pp. 119-124.

Singh PR, Singh Sukhbir and Singh AK. 2020. Tillage equipment for sugarcane cultivation. pp. 22-30.

Singh RD, Kumar Dilip and Singh Jaswant. 2020. Drying of jaggery using solar energy. pp. 166-171.

Singh SN, Singh VK, Patnaik JR and Gupta C. 2020. Agro-technology of sugarcane planting and intercropping system for higher yield and profit in sub-tropical India. pp. 39-48.

Singh, Sukhbir and Singh AK. 2020. Mechanization of sugarcane interculturing and earthing up operation. pp. 71-75.

Singh Sukhbir and Singh AK. 2020. Improved hand tools and equipment for sugarcane cultivation. pp. 63-70.

Singh Sukhbir, Singh PR and Singh AK. 2020. Status of sugarcane mechanization in India. pp. 14-21.

Others

Srivastava S and Kumar Pavan. 2020. Abiotic stress responses and tolerance mechanisms for sustaining crop productivity in sugarcane. *In* : Agronomic Crops, Volume 3: Stress Responses and Tolerance, (Ed M Hasanuzzaman), Springer Nature Singapore Pte Ltd. 2020. ISBN 978-981-15-0024-4 ISBN 978-981-15-0025-1 (eBook) pp. 29-47, https://doi.org/10.1007/978-981-15-0025-1.

Goswami SK, Manzar N, Kashyap AS and Kumar R. 2020. Seed borne diseases of agricultural crops: Detection, diagnosis and management. *In*: R, Kumar and A. Gupta (Eds.) Contribution of Individuals and Organizations in the Development of Seed Pathology. Springer Nature, ISBN-978-981-329-045-7. pp. 65-80.

Goswami SK and Singh V. 2020. Biotechnology in food production and food security. *In*: Verma T. and Prasad S (Eds.) RNA Interference Technology: Latest Advances and Applications in Crop Protection. Shree Publishers and Distributors ISBN: 978–81–8329–997–8 New Delhi. pp.13-35.

Holkar SK, Sandra N and Jain RK. 2020. Genetic diversity, transmission and understanding of seed borne viruses and phytoplasma. *In*: Seed-Borne Diseases of Agricultural Crops: Detection, Diagnosis and Management by Ravindra Kumar and Anuja Gupta (Eds.) Publisher: Springer. pp. 329-353.

Jaiswal AK, Roy Sharmila and Roy MM. 2019. Lac based agroforestry system for degraded land. *In*: Agroforestry for Degraded Landscapes: Recent Advances and Emerging Challenges (Eds. JC Dagar, SR Gupta and Demel Teketay) Vol. 2. ISBN 978-981-15-6806-0.

Joshi Deeksha, Upadhyay Monika and Tiwari Raghavendra. 2021. Management of Fungal Diseases of Crops through Plant Based Natural Products and Biopesticides. *In*: Biopesticides in Organic Farming (Ed. LP Awasthi) CRC Press, pp.: 392 ISBN 9780367460174.

Kumar A, Tiwari V, Singh P, Bishi SK, Gupta CK and Mishra GP. 2020. Advances and Challenges in Sugarcane Biofuel Development. *In*: Kumar N. (Ed.) Biotechnology for Biofuels: A Sustainable Green Energy Solution. Springer, Singapore. DOI https://doi.org/10.1007/978-981-15-3761-5_11.

Kumar Manoranjan, Srinivasarao CS, Rajput Jithendra NL, Kushwaha VA, Blessy Nivesh Shreya, Paramaguru PK and Rao KV. 2020. Climate change and Indian Agriculture: Challenges and Adaptation Strategies. ICAR-National Academy of Agricultural Research Management, Hyderabad, Telangana, pp.157-182.

Mall AK, Misra Varucha, Pathak AD, Singh BD and Bhatt Rajan. 2020. Advance production technologies of sugarcane : A step towards higher productivity. *In* : Advances in Crop Production & Climate Change (Eds. AS Yadav, Narendra Kumar, Sanjay Arora, DS Srivastava and Hemalata Pant). New India Publishing Agency, New Delhi. pp. 185-214.

Mall AK, Misra V, Singh BD, Kumar M and Pathak AD. 2020. Drought tolerance : Breeding efforts in sugarcane. *In* : Agronomic Crops (Ed. Mirza Hasaanzuman). Springer Nature Singapore Pte Ltd. Publications, pp 157-172.

Mall AK, Misra V, Pathak AD, Singh BD and Bhatt R. 2020. Advance Production Technologies of Sugarcane : A Step towards Higher Productivity. In : Yadav AS, Kumar N, Arora S, Srivastava DS and Pant H (Eds) Advances in Crop Production &

Climate Change. New India Publishing Agency New Delhi, pp. 185-214.

Misra V, Mall AK and Pathak AD 2020. Sugarbeet: A sustainable crop for salt stress conditions. In: Agronomic Crops (Ed. Mirza Hasaanzuman). Springer Nature Singapore Pvt. Ltd. Publications, pp. 40-62.

Modi Rajesh U., Manjunatha K., Gautam Prem Veer, Nageshkumar T, Sanodiya R, Chaudhary V, Murthy G.R.K., I. Srinivas and Ch. Srinivasa Rao. (2020). Climate-smart technology based farm mechanization for enhanced input use efficiency. *In*: Ch. Srinivasarao *et al.*, (Eds). Climate Change and Indian Agriculture: Challenges and Adaption Strategies. ICAR-National Academy of Agricultural Research and Management, Hyderabad, Telangana, pp. 325-357.

Singh SR, Yadav P, Choubey AK and Tripathi MK. 2020. Soil quality assessment: Concept and method for identification of soil quality indicators and computing soil quality index. 2020. *In*: Doubling Farmers Income through Appropriate Agricultural Technologies and Extension Approaches. Pp.15-36.

Srivastava S and Kumar Pavan. 2020. Abiotic Stress Responses and Tolerance Mechanisms for Sustaining Crop Productivity in Sugarcane. *In*: Hasanuzzaman M. (Ed.) Agronomic Crops, Volume 3: Stress Responses and Tolerance, Springer Nature Singapore Pte Ltd. 2020, ISBN 978-981-15-0024-4 ISBN 978-981-15-0025-1 (eBook) Pp. 29-47. https://doi.org/10.1007/978-981-15-0025-1

Tripathi MK, Choubey AK, Singh SR, Singh VK and Dwivedi AP. 2020. Recent advances in sugarcane production technologies. *In*: Doubling Farmers Income through Appropriate Agricultural Technologies and Extension Approaches. Pp. 231-226.

Technical Bulletins

Dwivedi AP, Shukla SK, Pathak AD and Singh AK. 2020. Sugarcane Based Integrated Farming System for Enhancing Crop Productivity and Farmers Income. Extension Bulletin, ICAR-IISR, Lucknow. 12 p.

Shukla SK, Nagargade Mona, Pathak AD and Blessy VA. 2020. Water Footprint in Sugarcane, ICAR-IISR, Lucknow, 36 p.

Singh SN, Pathak AD, Srivastava TK, Sah AK and Gupta C. 2020. Cane node technology for sugarcane planting. ICAR-Indian Institute of Sugarcane Research, Lucknow, 44 p.

Popular Article

Ansari MH. 2020, *Mahamaree Covid-19: Naye Aayaam Hetu Avsar. Ikshu* 9 (1): 67.

Anwar SI, Tiwari Mithilesh and Singh Priyanka. 2020. *Gud Ka Swad, Gulab Ki Sugandh- Gulab Wala Gud. Ikshu* 9 (1):109.

Brahm Prakash. 2020. *Corona Mahamari- Sab Par Bharee. Ikshu* 9 (1): 120.

Brahm Prakash. 2020. *Bharat Ki Aatmnirbharta Hee Laegi Desh Mein Sampannta. Ikshu* 9 (2): 101-102.

Brahm Prakash, Singh Abhishek Kumar and Sah AK. 2020. *Aatmnirbhar Bharat Mein Sashakt Rajbhasha Hindi Tatha Any Kshetreey Bhashaon Kee Bhoomika. Ikshu* 9 (2): 1-2.

Brahm Prakash, Gangwar LS, Om Prakash, Sachan AK, Sawnani Anita and Singh Kamini. 2020. *Aatmnirbhar Bharat Hi Dilaega Aarthik Swatantrata. Ikshu* 9 (2): 11-15.

Brahm Prakash, Singh AK and Om Prakash. 2020. *Safalta Kee Manzil Kee Mangal Yeatra. Matasya Lok* 8: 100-104.

Brahm Prakash. 2020. *Paanee Peete Samay Rakhien ye Dhyaan, Nahin Hoga Swasthy Ko Koi Nuksaan. Matasya Lok* 8 : 113-114.

Chandra A, Singh CP, Singh RK and Jain R. 2020. *Covid-19 Mahamaari Evem Ganna Shodh: Karyiki - Jaiv Rasayanik Tatha Aanvik Paripreksh*y. *Ikshu* 9 (1): 32-33.

Chandra Madan. 2020. *Aatmnirbhar Bharat Mein Krishi Kshetr Ka Vishisht Yogdaan. Ikshu* 9 (2) : 37-38.

Dheengra Amita, Sawnani Anita and Pathak AD, 2020. *Corona Sankraman Mein Aapka Aahaar V Jeevan Shailee. Ikshu* 9 (1): 106-108.

Dwivedi AP, Pathak AD, Singh SK, Tripathi MK, Shukla SK, Singh KK, Singh SN, Singh SR, Singh VK, Shukla AK and Singh Abhishek Kumar. 2020. *Havt Grah : Siddhant Evan Udyog* 9 (1): 72-75.

Gangwar LS, Brahm Prakash, Sah AK, Singh Abhishek Kumar, Yadav Ashish Singh and Singh Kamini. 2020. *Corona Mahamari Ke Daur Mein Pravasee Majdooron Ke Rojgar Ke Naye Avsaron Ke Liye Sarkari Prayas*. Ikshu 9 (1) : 26-28.

Goswami SK, Singh D, Joshi D, Raj C, Singh Shweta and Singh MR. 2020. *Ganne Ka Ukatha Rog :Parichay Aur Prabandhan. Ikshu* 9 (2) : 90-92.

Goswami SK. 2020. Guava wilt: A challenge in Plant Pathology. Krishi Jagran, https://krishijagran.com/featured/guava-wilt-a-challenge-in-plant-pathology/.

Goswami SK. 2020.*Kavak Se Hone Wale Dhaan ke Pramukh Rog Evam Nidaan. Krishi Kiran* 10: 10-14 http://saaer.org.in(April-June), 2020,eISSN: 2321-0001.

Kumar D, Mall AK, Misra V and Santeshwari. 2020. *Corona Virus Rog-19 :Vishvvyapi Mahamaree. Ikshu* 9 (1): 64-65.

Kumar D, Mall AK, Misra V, Santeshwari, and Pathak AD. 2020. *Jaevik Krishi Ki Naveentam Takneeki Ka Sanchalan Evam Lagat Ko Ghatane Ki Ranneeti. Grameen Vikas Sandesh.* Jan –Dec 2020. pp. 122-124.

Kumar Dilip, Prasad K, Verma RR and Lal B. 2020. *Pedhi Ganna Kheti Mein Patai Prabandhan: Karya Vidhi Evam Labh. Ikshu* 9 (1): 70-71.

Kumar Mukund, Mall AK and Singh SP. 2020. *Jaanein Kya Hai Refractometer. Ikshu* 9 (2): 81.

Kumar Raghvendra and Srivastava S. 2020. *Corona Lockdown Bana Kisanon Ke Rahat Kee Saugat. Ikshu* 9 (1): 55-59.

Kumar Raghvendra and Srivastava S. 2020. *Ganne Ki Phasal Mein SutrakrimiNiyantran. Ikshu* 9 (2): 62-63.

Kumar Raghvendra. 2020. *Aapda Ko Avsar Mein Badalne Ki Sankalpna: Aatmnirbhar Bharat. Ikshu* 9 (2): 16-19.

Kumar Raghwendra and Srivastava Sangeeta. 2020. *Jalvayu Parivartan: Vinash Ki Or Badhte Kadam. Krishi Chetna,* ICAR-Indian Institute of Maize Research, Ludhiana, **3**: 62-63.

Kumar Raghwendra and Srivastava Sangeeta. 2020. *Kushal Prakshetra Prabandhan Ke Ayaam. Krishi Chetna,* ICAR-Indian Institute of Maize Research, Ludhiana, **3**: 73-76.

Kumar Suraj and Anwar SI. 2020. *Corona Insanon Ke Prati Prakriti Ka Gussa. Ikshu* 9 (1): 121.

Kumar Suraj, Patel A, Markam SK, Anwar SI and Kumar D. 2020. *Gud Banane Hetu Teen Kadahee Bhatthee Ka Nirmaan. Ikshu* 9 (2): 75-76.

Kumar Suresh. 2020. *Basant Ke Dohe. Ikshu* 9 (2): 103.

Kumar Yeetesh, Singh Abhishek Kumar, Bharvawa Pankaj and Chandrakar A. 2020. *Krishi Mein Pakkshiyon Ka Aarthik Mahatva. Ikshu* 9 (1): 81-82.

Lal RJ and Singh MR. 2020. *Corona (Covid-19) Mahamari Ka samajik Aatmnirbharta, Aarthik Vyavastha, Paryavaran Evam Prabhavi Shramikon Ka Prabhav. Ikshu* 9 (1) : 12-18

Lal RJ and Singh MR, 2020. *Corona Sankraman Kaal Mein Krishi Hee Jeevan Daata. Ikshu* 9 (1): 29-31.

Lal RJ and Singh MR, 2020. *Ganne Ke Atirikt Ethenol Ke Any Vaikalpik Strot. Ikshu* 9 (2): 64-66.

Mall AK, Misra V, Malviya Amit, Kumar Dhirendra and Singh BD. 2020. *Ganne Ke Swasth Aur Gunvattapoorn Beej Utpadan Hetu Phasal Prabandhan. Ikshu* 9 (1): 68-69.

Markaam SK, Patel Akash, Kumar Suresh, Anwar SI and Banerji Tanushree. 2020. *Aatmnirbhar Bharat. Ikshu* 9 (2) : 103.

Mall AK, Misra Varucha, Santeshwari, Kumar Dharmendra and Kumar Ashwani. 2020. *Chukundar Mein Akarikajad Viglan. Gramin Vikas Sandesh,* Jan-December, pp. 22-23.

Mall AK and Misra V. 2020. *Kaafi Labhdayak Hai Ganne Ki Kheti. Samachar Patra: Prabhat Khabar Ank Kheti Badi:* Muzaffarpur. February 22, 2020.

Mall AK and Misra V. 2020. *Gud Utpadan Se Hoga Adhik Munafa. Samchar Patra: Prabhat Khabar Ank Kheti Badi:* Muzaffarpur. March 7, 2020.

Mall AK, Misra V, Santeshwari, Kumar D and Pathak AD, 2020. *Chukander Dwara Kam Lagat Evam Adhik Jaivethenol Ka Utpadan. Soyvritika.* pp. 61-62.

Mall AK, Misra V, Santeshwari, Kumar D and Pathak AD, 2020. *Fangy/Kantedar Jaden: Chukander Mein Aakari Ka Jadviglan. Grameen Vikas Sandesh* Jan –Dec 2020 pp. 22-23.

Mall AK, Misra V, Santeshwari, Kumar D and Pathak AD 2020. Fangy roots: Morphological root deviation in sugar beet. *Agriculture and Food e Newsletter* **2**(8): 975-976.

Mall AK, Misra V, Srivastava S and Pathak AD, 2020. Sugarbeet: An alternative crop for bio-ethanol production in India. *Indian Farming* **70**(06): 34-37.

Mall AK, V Misra, Kumar D and Pathak AD. 2020. *Ganne Mein Antarfasliya Kheti Kar Kisaan Payein Labh. Kheti.* pp 33-35.

Mishra Poonam Manish. 2020. *Aatmnirbhar Bharat Ke Liye Krishi Ko Denee Hogi Sarvochch Prathmikta. Ikshu* 9 (2): 20-21.

Misra Varucha and Mall AK. 2020. Nano-priming: An emerging technology for quality sugar beet seed production. *Agriculture & Food: e-Newsletter* **2**(5): 268-269.

Misra Varucha and Mall AK. 2020. *Corona Mahamari Ka Bharat Ki Cheeni Uddyog Evam Kisanon Par Prabhav. Soyvritika*. pp. 51-52.

Misra Varucha, Mall AK and Pathak AD. 2020. *Jal Sanrakshan Kar Payen Chukundar Ki Uchch Upaj. Phal-Phool*, September-October. pp. 42-44.

Misra V, Mall AK, Santeshwari, Kumar D and Pathak AD. 2020. *Covid-19 Mahamaree Ka Krishi Evam Sambandhit Kshetron Par Prabhav. Ikshu* **9** (1): 60-61.

Misra V, Santeshwari, Kumar D, Pathak AD and Mall AK. 2020. *Chukander Beej Peleting: Gunvatta Wale Beej Utpadan Hetu Ek Vridhi Takneek. Grameen Vikas Sandesh*. Jan –Dec 2020. pp. 103-105.

Misra V, Santeshwari, Kumar D, Pathak AD and Mall AK. 2020. Nano-Priming: *Gunvatta Wale Chukander Ke Utpadan Ke Liye Ek Ubharti Hui Takneek. Kisaan Kheti* **7** (2): 4-5.

Misra V, Santeshwari, Kumar D, Pathak AD and Mall AK. 2020. Sugar beet seed pelleting: An augmentation technique for quality seed production. *Agriculture and Food e-Newsletter* 2(8): 965-966.

Nagargade Mona. 2020. *Aatmnirbhar Bharat Abhiyaan Evam Krishi Kshetr Ek Dusre Ke Purak. Ikshu* 9 (2): 46-47.

Om Prakash, Brahm Prakash, Yadav P, Sah AK, Singh Abhishek Kumar, Singh Kamini and Yadav AS. 2020. *Corona Se Bachav Hetu Mask Ka Prayog Karte Samay Dhyan Rakhne Yogya Kuchh Vishesh Batein. Ikshu* **9** (1): 100-102.

Om Prakash, Yadav P, Brahm Prakash, Sah AK, Pathak AD, Singh Kamini and Singh Abhishek Kumar. 2020. *Aatmnirbhar Bharat Banane Mein Krishi Kshetr Ki Mahatvpoorn Bhoomika. Ikshu* 9 (2): 30-33.

Om Prakash, Sah AK, Pathak AD, Brahm Prakash and Yadav Pallavi. 2020. *Chini Parta Evam Upaj Badhane Mein Sahayak Unnat Sasya Kriyaein. Sahkari Chini Sandesh*. **2**(3):16-18.

Pandey Deepak, Shukla SK, Kumar M, Pandey M and Awasthi SK. 2020. *Varsha Jal Sanchit Kar Krishi Utpadakta Mein Vriddhi Kaise Karein? Ikshu* **9** (1): 79-80.

Patel Akash, Markarm SK, Kumar S, Anwar SI and Kumar Dilip. 2020. *Ganne Ke Ras Se Ethenol Ka Utpadan. Ikshu* **9** (1): 94-95.

Pathak AD and Sah AK. 2020. *Covid-19 Sankraman Mein Ganne Kee Kaise Karein Hifazat. Sugar Times* **3** (1): 15-16.

Rai Deepak, Singh Abhishek Kumar and Shakya RL. 2020. *Vaishvik Mahamaree Covid-19 Ke Paridrishy Mein Bharteey Krishi. Ikshu* **9** (1): 45-46.

Rai Deepak, Dubey Abhishek Kumar, Singh SN and Pathak AD. 2020. *Corona Kaal Mein Krishi Utpaad. Vikray Hetu Kisan Utpadak Sangathan Ke Praveshan Kee Krishi Vigyan Kendra, Lucknow Kee Ek Pahal. Ikshu* **9** (1): 62-63.

Rai RR, Tiwari Mithilesh, Singh Priyanka and Kumar D. 2020. *Ganne Ke Utpaad Mein Mulya Samvardhan. Ikshu* **9** (2): 60-61.

Roy MM and Chandra A. 2020. Optimizing sugar recovery in India: Need for an Integrated approach. *Acta Scientific Agriculture*, **4**: 1-6

Sachan AK, Kumar Rajesh, Sharma AK, Singh AK and Brahm Prakash. 2020. *Kisanon Kee Aay Doogunee Karne Hetu Shookar Palan Ek Uttam Vyavsaay. Matasya Lok* **8** : 96-99.

Sachan AK, Kumar Rajesh, Singh NK, Brahm Prakash, Singh AK and Tomar M. 2020. *Covid-19 Mahamaree Ke Dauraan Kheti Hee Bane Bharteey Arthvyavastha Ka Mukhya Aadhaar. Ikshu* **9** (1) : 41-42.

Sachan AK, Brahm Prakash and Singh Abhishek Kumar. 2020. *Covid-19 Vaishvik Mahamaree Ke Dauraan Bharat Ko Aatmnirbhar Banane mein Krishi Ka Yogdaan. Ikshu* **9** (2): 34-36.

Sah AK. 2020. Covid-19 *Mahamari Mein Krishi KeLiye Kya Sandesh Hai? Ikshu* **9** (1): 19-20.

Saini Manisha. 2020. *Vikas Ki Disha Mein Agrsar Hone Hetu Aatmnirbhar Bharat Mein Krishi Ka Yogdaan. Ikshu* **9** (2): 53-55.

Santeshwari, Mall AK, Varucha V and Kumar D. 2020. *Laghu Evam Seemant Kisanon Par Corona Virus Ka Kuprabhav. Ikshu* **9** (1): 50-51.

Santeshwari, Mall AK, Misra V and Malaviya Amit. 2020. *Chukander Mein Ekikrit Keet Prabandhan. Soyvritika*. **1**: 69-70.

Sawnani Anita. 2020. *Aatmnirbhar Bharat Ki Or Gramin Mahila Ke Badhte Kadam. Ikshu* **9** (2): 48-49.

Sawnani Anita, Dheengra Amita, Brahm Prakash, Singh Kamini and Pathak AD, 2020. *Covid Se Bachate Bharat Ke Phal. Ikshu* **9** (1):103-105.

Shakya RL, Rai Deepak, Kumar A, Tomar M, Morya AK and Yadav U. 2020. *Covid-19 Mahamaree Ke Dauraan Soochna Evam Sanchaar Prodyogikee Ka Upyog Evam Mahatv. Ikshu* **9** (1): 39-40.

Sharma AK, Brahm Prakash, Om Prakash, Singh

Ashish Kumar and Singh Nagendra. 2020. *Covid-19 Mahamaari Ka Bharat Mein Ganna Evam Cheeni Kshetr Par Prabhav. Ikshu* **9** (1) : 21-25.

Sharma Lalan, Shukla SK, Jaiswal VP, Gaur Asha, Sahni Divya and Tiwari Raghvendra. 2020. *Aatmnirbhar Bharat Mein Krishi Kshetr Ki Mahtee Bhoomika. Ikshu* **9** (2) : 40-42.

Shiv Alok. 2020. *Kaise Krishi Aatmnirbhar Bharat Mein De Sakti Hai Yogdaan? Ikshu* **9** (2): 4-8.

Shukla SK. 2020. *Corona Kaal Par Sawaiya Chhand. Ikshu* **9** (1):119.

Shukla Jatakant. 2020. *Krishi Ko Sammanjanak Sthan Die Bina Aatmnirbhar Bharat Ke Bare Mein Sochna Beimaani. Ikshu* **9** (2): 45.

Singh Abhishek Kumar, Brahm Prakash, Sah AK, Shukla SK, Singh RK and Singh N. 2020. *Sahitya Jagat Par Corona Ka Prabhav. Ikshu* **9** (1): 10-11.

Singh Abhishek Kumar, Brahm Prakash, Sah AK, Sachan AK and Singh Kamya. 2020. *Aatmnirbhar Ke Liye Bhasha Ka Mahatv. Ikshu* **9** (2): 3.

Singh AK, Brahm Prakash and Yadav AS. 2020. *Smartphon Se Duri Banana Kyon Aavashyak Matasya Lok* **8** : 110-112.

Singh CP and Singh D. 2020. *Ganna Kisanon Evam Chenee Udyog Par Corona Mahamaree Ka Prabhav. Ikshu* **9** (1): 47-49.

Singh Ganesh. 2020. *Aatmnirbhar Bharat Ki Dhuri-Krishi. Ikshu* **9** (2): 22.

Singh Kamini. 2020. *Aatmnirbhar Bharat Ki Buniyaad: Krishi. Ikshu* **9** (2):23-26.

Singh Kamini, Gangwar LS, Brahm Prakash and Sawnani A. 2020. *Corona Mahamaree Ka Bauddhik Sampada Adhikaar Par Prabhaav. Ikshu* **9** (1): 36-38.

Singh MR, Lal RJ, Baitha A, Sah AK, Kumar Anuj, Maurya IP, Dixit Shivani and Yadav, Neetu. 2020. *Chukandar Ki Vaigyanik Kheti. Ikshu* **9** (2): 68-74.

Singh PK. 2020. *Krishi Ki Atma : Paudha Kismon Ka Bharat Ke Vikas Aur Aatmnirbharta Mein Yogdaan. Ikshu* **9** (2): 9-10.

Singh Pragati and Anwar SI. 2020. *Corona Virus Aur Samaj. Ikshu* **9** (1): 97

Singh Priyanka and Tiwari Mithilesh. 2020. *Aatmnirbhar Bharat Hetu Krishi Karya Ko Dena Hoga Aur Mahatv. Ikshu* **9** (2): 39.

Singh Pushpa and Anam. 2020. Green chemistry for sustainable agro-entrepreneurship, *Flora Sarthi*, 3: 1-4.

Srivastava TK, Singh Pushpa and Verma RR. 2020. Farming adaptation needs against long term climate change in sub-tropics. *Jagriti* **36**: 39-45.

Singh RK, Sharma AK, Simgh VN, Singh V, Rai D, Singh Abhishek Kumar and Singh Nagendra. 2020. *Lockdown Ke Dauraan Dairy Vyavsaay Mein Bharee Aarthik Kshati Par Ek Najar. Ikshu* **9** (1): 43-44.

Singh RK, Singh Kamya and Singh SK. 2020. *Aatmnirbhar Bharat Mein Krishi Kshetr Ka Yogdaan. Ikshu* **9** (2): 50-52.

Singh Smita. 2020. *Aatmnirbharata Ki Dagar Par Aage Badhaegi Krishi. Ikshu* **9** (2): 27.

Singh SN., Pathak AD., Singh, VK. and Gupta, C. 2020. *Uttar Pradesh mei Basant Kaleen Ganne Ki Phasal Utpadan Takniki Evam Sahphasali Kriya Vidhiyan. Khad Patrika,* **61** (03): 09-18.

Singh SN and Pathak AD 2020. *Jal Sankat Se Joojhati Maharashtra Me Ganne Ki Kheti: Aakalan Avam Tikau Utpadan Ke Sambhavit Upaay. Khad Patrika,* **61** (08): 08-23.

Singh Sukhbir. 2020. *Arthvyavastha Ke Sudridheekaran Hetu Aatmnirbhar Bharat Ka Mahatv. Ikshu* **9** (2): 28-29.

Singh Sukhbir, Singh AK and Singh MK. 2020. Covid-19 *Mahamaaree Ke Dauraan Shramikon Kee Kamee Ko Dekhte Hue Ganne Kee Kheti Hetu Unnat Yantra. Ikshu* **9** (1): 34-35.

Singh Veenika, Shahi VP and Singh VN. 2020. *Aatmnirbharta Se Behtar Koi Vikalp Nahin. Ikshu* **9** (2): 58-59.

Singh YM, Brahm Prakash and Yadav AK. 2020. *Mobile Phone Se BheeAchchhe Photograph Kheenchna Sambhav. Ikshu* **9** (1): 116-118.

Srivastava AK, Tiwari Raghvendra, Jaiswal VP, Srivastava Priyanka and Gaur Asha. 2020. *Lemongrass Ke Aushadheey Upyog Evam Iski Vaigyanik Kheti. Ikshu* **9** (1): 111-112.

Srivastava S and Kumar Raghvendra. 2020. *Covid-19 Sankat Se Nipatne Mein Kisanon Kee Madad Ke Liye Sarkaree Upay. Ikshu* **9** (1): 52-54.

Srivastava Sangeeta. 2020. *Fasal Sudhar Ke Liye Prajnan Takneek "Genome Editing": Anuprayog, Kshamta Aur Chunautiyan. Krishi Chetna.* ICAR-Indian Institute of Maize Research, Ludhiana **3:** 90-93.

Srivastava TK, Singh Pushpa and Verma Ram Ratan. 2020. *Ganne Ki Kheti Mein Fayademand Jaivik Karbon. Kheti.* Dec. 2020: 33-35.

Swapna M and Solomon S. 2020. Green technologies in sugarcane agriculture: Mitigating climate change. *IAPSIT Newsletter* **12**(1&2): 2-3.

Tiwari, Raghvendr, Shukla SK, Jaiswal VP, Srivastava AK, Awasthi SK and Tiwari RK. 2020. *Pokkah Boeng – Ganne Ke Phasal Kee Ubhartee Hui Beemaree. Ikshu* **9** (1): 92-93.

Tiwari Mithilesh, Rai RR, Kumar D and Singh AK. *Manav Jeevan Ke Liye Vardaan; Ganne Ka Gud. Ikshu* **9** (1):110.

Tiwari Mithilesh, Kumar D, Rai RR and Singh AK. 2020. *Cheeni Haanikarak: Gud Labhdayak. Ikshu* **9** (2): 96.

Tiwari Mithilesh, Singh Priyanka and Kumar D. 2020. *Aatmnirbhar Bharat Mein Krishi Kshetr Ka Yogdaan. Ikshu* **9** : 243-44.

Yadav AS, Brahm Prakash and Sah AK. 2020. *PradushitVatavaran Mein Bhee Jaanleva Beemariyon Ke Khatre Ko Kam Karne Mein Sahayak Gud. Ikshu* **9**(2): 99.

Yadav N. 2020. *Ganne Ki Vaigyanik Vidhi Se Beej Ka Utpadan. Ikshu* **9** (2): 67.

Yadav SK, Singh AK, Shukla SK, Jaiswal VP and Baitha A. 2020. *Tulsi Kee Kheti Corona Parivesh Mein Aay Ka Sunhara Avsar. Ikshu* **9** (1): 76-78.

Yadav SK, Shukla SK, Singh AK, Jaiswal VP, Baitha A and Pathak AD. 2020. *Aatmnirbhar Bharat Mein Ganna Adharit Phasal Paddhati Ka Aushadheey Tatha Sugandhit Paudhon Dwara Vividhikaran. Ikshu* **9** (2): 56-57.

Yadav Sarala, Kumar Alok and Yadav SK. 2020. Bamboo - The Green Gold. *Indian Farmers' Digest. 53 (8)* : 40-42.

Sah AK. 2020. *Ganna Kisanon Kee Aay Doguna Karne Mein Samekit Prasaar Karyakram Ka Mahatv. Sugar Times* : **2** (10) 13-15.

Sah AK. 2020. Covid 19 *Vaishvik Mahamari Ke Karan Krishi Mein Utpann Samasyaon Ka Kya Hai Samadhan? Sugar Times* **3** (2): 25-26.

Sah AK. 2020. *Ganne Kee Adhik Upaj Ke Lie Anta:Karshan Evam Phasal Suraksha Prabandhan. Sugar Times* **3** (4) : 15.

Sah AK. 2020. *Paryavaran Evam Jal Sanrakshan-Kya Aur Kaise? Sugar Times* **3** (5) : 21.

Sah AK. 2020. *Swadeshi Vigyan Se Banega Bharat Aatmnirbhar. Sugar Times* **3** (6) : 25.

Sah AK. 2020. *Saat Nai Prajatiyon Se Cheeni Aur Ethanol Ki Puree Hongee Maang. Sugar Times* **3** (7) : 11.

Sah AK. 2020. Livelihood for Migrants in Sugarcane Sector. *Sugar Times* **3** (8): 31.

Sah AK. 2020. Covid- 19: Challenges and mitigation measures. Published online in ANN (Agri News Network) of Agriculture Today Group 2020, (Articles), agrinewsnetwork.in/articles.php#art_130. Accessed on 17 June 2020.

Sah AK. 2020. *Corona Sankat Mein Chhoti-Chhoti Prasanskaran Ikaiyaan Hee Krishi Ko Aarthik Nuksaan Se Bacha Sakti Hai.* Published online in *Gaon Connection*, May 22, 2020. https://www.gaonconnection.com/desh/in-the-corona-crisis-only-small-processing-units-can-save-the-agriculture-sector-from-economic-losses-47594

Sah AK. 2020. Small processing units can help the agriculture sector tide over the current economic crisis. Published online in *Gaon Connection*, May 26, 2020. https://en.gaonconnection.com/small-processing-units-can-help-the-agriculture-sector-tide-over-the-current-economic-crisis-that-has-emerged-due-to-coronavirus/

Sah AK. 2020. *Paryavaran Evam Jal Sanrakshan Ke Lie Sabhi Ko Ek Saath Aana Hoga.* Published online in Gaon Connection, July 7, 2020. https://www.gaonconnection.com/desh/everyone-has-to-come-together-for-environment-and-water-conservation-47789

Sah AK. 2020. *Phasal Evam Utpaad Vividhikaran Kyon Hai Aavashyak? Krishak Jagat*, Bhopal, October 19, 2020, p. 8.

Folders

Chandra A, Malaviya DR, Joshi D, Brahm Prakash and Sawnani A (Eds.), 2020, Year at a Glance, ICAR-IISR, Lucknow, 6 p.

Kumar Sanjeev and Singh Praveen Kumar. 2019. *Bharteeya Ganna Anusandhan Sansthan, Lucknow Dwara Viksit Naveen Ganna Kismein*, ICAR-IISR, Lucknow, 8 p.

Singh SR, Srivastava TK, Tripathi MK and Dwivedi AP. 2020. Balanced fertilizers use ready reckoner for plant crop of sugarcane. Bilingual Extension Folder 01/2020. 6 p.

Singh SR, Srivastava TK and Tripathi MK. 2020. Balanced fertilizers use ready reckoner for sugarcane ratoon. Bilingual Extension Folder 02/2020. 6 p.

Radio/TV Talks

Dr. S.N. Singh, Principal Scientist delivered a talk entitled *Basant Kaleen Ganne Ki Kheti Vasahphasali Kriya Vidhiyan* on All India Radio on February 04, 2020.

Dr. S.N. Singh, Principal Scientist delivered a talk entitled *Ganna-Kheti Me Samsamayik Prabandhan* on Doordarshan DD Kisan, New Delhi on July 30, 2020,

Dr. S.N. Singh, Principal Scientist delivered a talk entitled *Sharad Kaleen Ganne Ki Buwai Vidhiyan Avam Saphasali Kheti* on Doordarshan Kendra, Lucknow on September 16, 2020.

Dr. T.K. Srivastava, Principal Scientist delivered a talk on *Sharad Kaleen Ganne Ki Unnat Kheti* which was broadcast on September 12 and 15, 2020.

Success Story

Shri Chandra Shekhar Tiwari - A farmer with technological interventions of ICAR-IISR achieves high profit from sugarcane cultivation in Narsinghpur (Hoisted on *ICAR Website* dated: August 19, 2020)

CHAPTER 17

Technical Programme (2020)

Project Code	Title of the project
Division of Crop Improvement	
B1.7	Collection, maintenance, evaluation and documentation of sugarcane germplasm under sub-tropical conditions (P.K. Singh and Sanjeev Kumar, 01/95-LT)
B1.8	Defining ideotypes in sugarcane for moisture deficit conditions (A.K. Mall, D.R. Malaviya and S.P.Singh; 01/17-12/21)
B2.13	Development of sugarcane varieties for sub-tropics (Sanjeev Kumar, P.K. Singh and T.K. Srivastava; 10/03-LT)
B2.15	Developing sugar beet varieties for Indian agro-climates (A.D. Pathak, A.K. Mall and Arun Baitha; 09/08-LT)
B2.16	Development of sugarcane clones/varieties for North Central Zone (A.K. Mall, A.D. Pathak, D. Singh, Arun Baitha, M.K. Tripathi and C.K. Gupta; 10/18-09/28)
B3.19	Mapping of loci linked to sugar content in sugarcane (M. Swapna; 12/09-03/20)
B3.21	Production of disease free and genetically pure seed cane through tissue culture techniques (Sanjeev Kumar and S.K. Holkar; 11/13-LT)
B3.22	Development of *in vitro* conservation protocol using slow-growth tissue culture techniques in sugarcane (Sanjeev Kumar (Biotech.); 03/15-03/20)
B3.23	Profiling and prediction of small RNA transcriptomes in sugarcane in sugarcane inoculated with red rot pathogen (Sangeeta Srivastava, A.D. Pathak and Dinesh Singh, 10/15-10/20)
B3.24	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)
B3.25	Population improvement and development of genetic stocks for high sugar accumulation potential (Swapna M, Sanjeev Kumar (Plant Breeding) and Sanjeev Kumar (Biotech); 10/20 – 09/25)
AICRP on Sugarcane	
B1.1	Evaluation of early maturing sugarcane clones of North West Zone (Sanjeev Kumar and P.K. Singh, 02/09-LT)
B1.2	Evaluation of mid-late sugarcane clones of North West Zone (Sanjeev Kumar and P.K. Singh, 02/09-LT)
B1.3	Evaluation of sugarcane clones under Zonal Varietal Trials for North Central and Eastern Zone (A.K. Mall and A.D. Pathak; 02/09 - LT)
Externally funded	
DBT	Accredited Test Laboratory (ATL) under National Certification System for Tissue Culture Raised Plants (NCS-TCP) Coordinator: Sanjeev Kumar (Biotech.), PIs: Sanjeev Kumar and Dinesh Singh; 03/15-03/20, Budget : ₹ 103.00 lakh
DST-SERB	Genomic selection based accelerated breeding in sugarcane (*Saccharum* species complex) with special reference to sugar content and red rot resistance [Sanjeev Kumar (Biotech.), 06/18-06/21; Budget : ₹ 49.78 lakh]
DST WOS-A	Investigating sucrose accumulation through RNA-seq bulked segregant analysis in sugarcane (PI: Nandita 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; 03/15-03/20)
A 2.39	Synchronizing nutrient supply with crop demand under drip fertigation for upscaling nutrient use efficiency in sugarcane (Plant) ratoon system (K.K. Singh, S.R. Singh, V.P. Singh, S.K. Shukla, Rajendra Gupta; 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. Varma 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)
A 3.24	Enhancing system productivity and profitability of wide row planted autumn sugarcane through intercropping of high value crops (C. Gupta, A.K. Singh (Agron.), 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 – 03/20)
A 4.10	Developing sugarcane based Integrated Farming System Models for small farm holders of sub-tropical India (A.P. Dwivedi, T.K. Srivastava, S.K. Shukla, Niranjan Lal, A.K. Dubey, A.K. Sharma, Akhilesh Kumar Singh, Rakesh Kumar Singh, S.P. Singh and A.D. Pathak; 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, 2014-2020)

AS71	Carbon Sequestration assessment in sugarcane based cropping system (V.P. Jaiswal, S.K. Shukla, V.P. Singh; 2016-2020)
AS72 (A)	Agronomic performance of elite sugarcane genotype (Early) (V.P. Singh and S.K. Shukla; 2016-LT)
AS72 (B)	Agronomic performance of elite sugarcane genotype (Mid-late) (K.K. Singh and V.P. Singh; 2016-LT)
AS73	Assessment of climate change impact on sugarcane productivity (R.R. Verma and T.K. Srivastava; 2018-LT)
AS74	Evaluation of sugarcane varieties for drought tolerance (V.K. Singh, K.K. Singh and V.P. Singh; 2018-LT)
AS75	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; Duration: 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 02H and BAS 82201 H against weeds in sugarcane and its effect on succeeding crop (S.K. Yadav, A.P. Dwivedi, S.K. Shukla, A.D. Pathak, S.K. Holkar, 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)
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 (M.R. Singh 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 and S.K. Holkar, 05/15-04/22)
M 17	Evaluation/screening of sugarcane germplasm against red rot and smut (M.R. Singh and Dinesh Singh, 1992-93-LT)
M 15.6	Enhancing efficacy of *Trichoderma* based red rot management system (Deeksha Joshi and Pushpa Singh, 04/12-03/20)
M 15.7	Management of Pokkah boeng disease of sugarcane (Lalan Sharma, S.K. Shukla, V.P. Jaiswal and M.R. Singh: 03/19-02/23)
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)
Ento 15.3	Isolation, identification and synthesis of sex pheromones lures for the management of major borers of sugarcane (M.R. Singh, Pushpa Singh, A Baitha, S.N. Sushil and A.K. Jaiswal: 04/19-03/22)
Ento 15.4	Dispersal, host location, kairomonal effect and recovery of bio-agents *Trichogramma chilonis* and *Tetrastichus howardi* (A. Baitha, M.R. Singh, A.K. Jaiswal, S. Roy and S.N. Sushil: 10/18-09/22)
Ento 2.1.2	Developing arthropods-based soil health indicator for subtropical sugarcane ecosystem (Sharmila Roy, A.K. Jaiswal, D. Joshi and S.R. Singh: 10/18-09/23)
Ento 4.2.1	Development of eco-friendly technologies for the management of termites in sugarcane (S.N. Sushil, A.K. Jaiswal, S. Roy and D. Joshi: 10/18-09/22)
AICRP (S)	
Plant Pathology	
PP14	Identification of pathotypes in red rot pathogen (Dinesh Singh and Lalan Sharma)
PP17	Evaluation of zonal varieties against red rot, smut and wilt (Dinesh Singh and Lalan Sharma)
PP 22	Survey of sugarcane diseases naturally occurring in the area on important varieties (Dinesh Singh and Lalan Sharma)
Entomology	
E 4.1	Evaluation of varieties/genotypes for their reaction against major insect pests (M.R. Singh, A. Baitha and S.N. Sushil)
E. 30	Monitoring of insect pests and bio-agents in sugarcane agro-ecosystem (M.R. Singh, A. Baitha and S.N. Sushil)
E. 34	Standardization of simple and cost effective techniques for mass multiplication of sugarcane bio-agents (M.R. Singh, A. Baitha and S.N. Sushil)
E.39	Pilot evaluation of water less pheromone trap and water basin pheromone trap against sugarcane borers (Arun Baitha and M.R. Singh)
Contract Project	
Bayer Crop Science Ltd., Mumbai	Bio-efficacy of Vayego Superb (Tetraniliprole 0.4% + Fipronil 0.6% Gr against early shoot borer, top shoot borer and white grub in sugarcane (M.R. Singh and Arun Baitha; 05/18-05/20; Budget : ₹10.0 lakh)
United Phosphorus Ltd., Mumbai	Bio-efficacy 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; Duration: 04/12-03/22)
PB 29	Physiological and molecular base of multiple abiotic and biotic stress tolerance in sugarcane (S.P. Singh, Radha Jain, A. Chandra, A.K. Mall and A.D. Pathak, 04/17-03/22)
PB 30	Genome sequencing of red rot pathogen of sugarcane (A. Chandra, Sanjeev Kumar (Biotech.), D. Singh and Deeksha Joshi, 04/17-03/22)
PB 31	Understanding mechanisms of sugar accumulation and WUE in sugarcane through physio-bio-chemical studies (C.K. Gupta, S.P. Singh, Rajeev Kumar, A. Chandra, A.K. Mall, Bhupinder Singh, Rajesh Kumar, R. Jain and A.D. Pathak; 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, Radha 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, Radha Jain and Rajeev Kumar: 04/19-03/24)
Inter-Institutional Project	Screening and identification of sugarcane lines tolerant to water-logging and their physio-biochemical investigation (Radha Jain, A.D. Pathak, A. Chandra, S.P. Singh, M. Swapna, V.K. Srivastava, M. Ramadurai, 2013-2021)
Externally Funded Projects	
DST-SERB	Source-Sink dynamics in sugarcane-a global transcriptome analysis to decipher factor(s) controls sucrose content in cane stalk/culm (A. Chandra and 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; 09/16-08/20)
AE 1.52	Development and evaluation of tractor operated multipurpose tool frame with attachments for sugarcane (Sukhbir Singh and A.K. Singh, 10/15-09/20)
	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)
	Development of e-powered multipurpose equipment adapted to controlled traffic farming for sugarcane (M.K. Singh, A.K. Singh and Sukhbir Singh; 10/20-09/25)
AE 1.23	Development of cane node planter (A.K. Singh and S.N. Singh; 09/16-08/20)
AE 1.81	Development of sugarcane trash management machinery (M.K. Singh, A.K. Singh and R.D. Singh: 09/18-08/21)
AE 6.8	Sustaining sugarcane yield under multiple ratooning through drip irrigation (Rajendra Gupta; 03/16-03/22)
AE 7.1.1	Refinement of sugarcane cleaner cum washer for jaggery (S.I. Anwar, Dilip Kumar and R.D. Singh, 11/16-10/20)
AE 7.6.1	Development of integrated drying system for jaggery drying (R.D. Singh, A.K. Singh, S.I. Anwar and Dilip Kumar; 11/16-11/19)
AE 7.6.2	Development of a jaggery furnace with efficiency boosting device (S.I. Anwar, 04/12-03/20)
AE 7.6.3	Development of small powder jaggery cubes (Dilip Kumar, S.I. Anwar and R.D. Singh; 08/19-07/21)
AE 7.6.4	Process protocol for enhancing the shelf life of sugarcane juice (Dilip Kumar; 08/19-07/22)
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); 02/19-01/22)

AICRP on Farm Implements and Machinery	
FIM/IISR/PMW/86	Manufacturing of prototypes for conducting field adoptability trials under varying agro-climatic and soil conditions (A.K. Singh; 04/86-LT)
FIM/IISR/FLD/2017/01	IISR Tractor operated disc type ratoon management device (A.K. Singh, Sukhbir Singh and A.K. Sah; 04/17-03/20)
FIM/IISR/FLD/2017/02	IISR Tractor operated deep furrow sugarcane cutter planter (A.K. Singh, Sukhbir Singh and M.K. Singh; 04/17 to 03/20)
FIM/IISR/FLD/2017/03	IISR Tractor operated sugarcane trench planter (A.K. Singh, Sukhbir Singh and M.K. Singh; (04/17 – 03/20)
FIM/IISR/FLD/2017/04	IISR Tractor operated deep furrow sugarcane cutter planter/trench planter –cum- multicrop raised bed seeder (A.K. Singh and Sukhbir Singh; 04/17 - 03/20)
FIM/IISR/FLD/2020/1	IISR Tractor operated multipurpose interculturing equipment (Sukhbir Singh and A.K. Singh; 01/20 – 12/22)
AICRP on Post Harvest Engineering Technology (PHET)	
LKO/PHTS/16/01	Development of sugarcane juice extractor for house hold use (Dilip Kumar and S.I. Anwar; 01/16 – 03/20)
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 – 07/21; Budget : ₹10.84 lakh)
RKVY (U.P. Govt)	Establishment of quality jaggery production-cum-training unit in selected districts of Uttar Pradesh for income generation and entrepreneurship development (Dilip Kumar, A.D. Pathak, A.K. Singh and A.K. Mall, 04/18 – 03/20, Budget : ₹220 lakh)
DBT funded project under Women Scientist Scheme B (WoS-B)	Modified atmosphere packaging of sugarcane juice in closed system (PI: Priyanka Singh, Mentor: Dilip Kumar, 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 – 10/20)
ET 1.15	An analysis of gender perspective in sugarcane cultivation (Kamta Prasad, R.S. Dohare, A.K. Sah, Rajesh Kumar and A.K. Sharma; 01/17-12/20)
ET 1.16	Technology and information utilization pattern among the sugarcane growers (Barsati Lal, Kamta Prasad, R.S. Dohare, A.K. Sah, R. Gupta and L.S. Gangwar: 10/18-09/23)
Economics & Statistics/AKMU/PME Cell	
AES 4.15	Development of data mining and presentation tools in sugarcane (S.S. Hasan, Rajesh Kumar and L.S. Gangwar; 04/12-03/21)
AES. 4.16	Factors contributing to economic viability of sugar mills and energy production complexes in India (L.S. Gangwar, S.S. Hasan and A.K. Sah; 03/15 - 03/20)
AES 4.17	Impact of IISR technologies in sustaining sugarcane production in India (A.K. Sharma, T.K. Srivastava, A.K. Singh, A.D. Pathak and M.R. Singh; 04/15 – 03/20)
AES 4.19	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, 10/16-09/20)
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)

AES4.22	Development of district-level database on sugarcane growth and sustainability (A.K. Sharma and L.S. Gangwar; 08/19-07/22)
AES4.23	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)
AES4.24	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	
EM01	Survey and surveillance of insect-pests and diseases of sugarcane in sub-tropical area (M.R. Singh, HoD and all Scientists of IISR Biological Control Centre, Pravaranagar; LT)
M5.9	Genetic diversity and transmission of pathogens causing yellow leaf disease in sugarcane (S.K. Holkar, Arun Baitha and Sanjeev Kumar (Biotech.); 04/15 – 03/20)
BCC1.1	Bio-prospecting of entomopathogenic bacteria for management of white grubs infesting sugarcane (D.N. Borase, S.N. Sushil, D. Joshi, S.K. Holkar and Y.E. Thorat: 08/18-07/23)
BCC1.2	Utilization of entomopathogenic nematodes against white grubs infesting sugarcane (Y.E. Thorat, S.N. Sushil, D.N. Borase and S.K. Holkar: 08/18-07/23)
Externally funded project	
RKVY (Maharashtra)	Establishment of biological control laboratory for mass production of biological agents against sugarcane insect pests and diseases and dissemination of technology for enhanced cane and sugar productivity in Maharashtra (IISR, Lucknow) (S.N. Singh, M.R. Singh, Deeksha Joshi, Arun Baitha, S.K. Holkar, D.N. Borase and Y.E. Thorat; Budget: ₹ 5.0 Crore; 04/17-04/20).
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; 04/18-03/20, Budget : ₹ 15.0 lakh))

CHAPTER 18

Review, Monitoring and Evaluation

Research Advisory Committee Meeting

The XXVI Meeting of Research Advisory Committee of ICAR-Indian Institute of Sugarcane Research, Lucknow was held on December 15, 2020 on digital platform under the Chairmanship of Dr. S.K. Datta, Ex. Deputy Director General (CS), ICAR, New Delhi. The RAC members *viz.*, Dr. N. Vijayan Nair, Ex. Director, ICAR-SBI, Coimbatore; Dr. S.V. Sarode, Ex. Director of Research, Dr. PDKV, Akola; Dr. Indra Mani, Head, Division of Agricultural Engineering, ICAR-IARI, New Delhi; Sri R.L. Tamak, CEO and Executive Director, DCM Shriram, New Delhi; Dr. A.K. Vasisht, Ex. ADG (PIM), ICAR, New Delhi; Dr. J.P. Mishra, OSD, ICAR, New Delhi; Dr. R.K. Singh, Assistant Director General (CC), ICAR, New Delhi; Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow; Mr. Harveer Singh Gujjar, Mamuri Shahpur, District Meerut and Dr. Sangeeta Srivastava, Head (I/c), Division of Crop Improvement, ICAR-IISR, Lucknow and Member Secretary were present in the meeting. All the Heads of Divisions/In Charges of Sections, In Charges of RC, Motipur, BCC, Pravaranagar and Sugar Beet Breeding Outpost, Mukteswar, Head, KVKs of Lucknow and Lakhimpur Kheri as well as all the Scientists of the Institute also participated in the meeting as special invitees.

Dr. A.D. Pathak, Director, ICAR-IISR made a presentation on sugarcane scenario in the country and efforts of IISR. Dr. Sangeeta Srivastava, Head, Division of Crop Improvement; Dr. S.K. Shukla, Head, Division of Crop Production; Dr. M.R. Singh, Head, Division of Crop Protection; Dr. Radha Jain, Head, Division of Plant Physiology and Biochemistry; Dr. A.K. Singh, Head, Division of Agricultural Engineering; Dr. A.K. Mall, Principal Scientist & In-charge, IISR Regional Centre, Motipur (Bihar); Dr. D.N. Borase, Scientist &Incharge, IISR Biological Control Centre, Pravaranagar; Dr. A.K. Sah, Principal Scientist & Incharge, Training & Extension Unit; Dr. Rajesh Kumar, Principal Scientist and Incharge, AKMU Dr. L.S. Gangwar, Principal Scientist & I/c, PME Cell, Dr. A.K. Dubey, Head, KVK, IISR, Lucknow and Dr. Niranjan Lal, Head, KVK, IISR, Lakhimpur Kheri presented the research highlights

Research Advisory Committee congratulated IISR for development of number of sugarcane varieties and successful implementation of doubling the farmers' income and water saving projects in PPP mode with DCM Shriram Ltd. The RAC highlighted that sugarcane crop is very much prone to insect-pests and diseases and regular work on survey and surveillance being done by the Institute is commendable. The Committee also appreciated the bio-control work being done by the Institute. After critically analysing the achievements of the research activities, RAC members offered appropriate suggestions and made following major recommendations:

- Good work has been done on varietal development and it should be continue. Further, (i) The germplasm available at ICAR-IISR, Lucknow should be enlarged and characterized to develop trait specific gene pools and a database of trait specific parents should be developed. (ii) Efforts should be made to develop location specific varieties through a participatory plant breeding approach with the support of sugar industry.
- Genome editing in combination with accelerated breeding for specific traits should be initiated.
- Energy canes developed by ICAR-SBI, Coimbatore may be tested for their adaptability in sub-tropical India and IISR may develop their own energy canes as well. In this context, sugar beet may be explored for bioethanol & fodder production, and as an intercrop with sugarcane. A one-day brainstorming session may be organized at IISR to discuss the prospects of sugar beet with participation of industry people.
- Root studies including root architecture, growth, anatomy, length, density, volume *etc.*, may be taken up in relation to drought resistance.
- The projects like doubling farmers' income and water saving implemented by IISR, Lucknow in collaboration with DCM Shriram Ltd. should be replicated at other places with the collaboration of the Department of Agriculture and Cooperation (DAC). A multi-disciplinary and multiinstitutional approach along with the association of a socio-economic scientist from ICAR-NAARM, Hyderabad should be taken up in the future research programmes.
- Population of insects may be correlated with the parameters of climate change to strengthen the

forewarning and forecasting system for insect pests. Epidemiological studies on major diseases in last two decades should be taken up to combat the problems emerging due to climate change. IISR should have collaborative research project on sex pheromones with NCL, Pune and ICT, Hyderabad.

- Since quality seed is important for disease management especially red rot, and MHAT has played an important role in this regard, the Engineering Division should develop MHAT plants to reduce the incidence of red rot. Emphasis should also be given to produce disease free and genetically pure quality seed through micro propagation as well as conventional approaches.
- A Webinar should be organized with different start-ups and entrepreneurs taking help of Agrinnovate India and feedback to be collected from all the stakeholders. Information about IISR products should be available in a tabular form to increase their visibility. Solar energy based agricultural machineries should be tried especially for jaggery production.
- Capacity development of research laboratories and research facilities for future research programmes should be promoted. Impact assessment of technologies on livelihood and lifestyle changes should also be studied in addition to income. A team should be constituted for generating the primary data.
- The KVKs of IISR, Lucknow should play a proactive role in disseminating the IISR developed technologies like IFS model, seed production *etc.* Fund should be allocated to KVK, Lakhimpur Kheri for Tribal Sub Plan.

Institute Research Council Meeting

The Institute Research Council (IRC) Meeting of the ICAR-Indian Institute of Sugarcane Research (IISR), Lucknow was held under the Chairmanship of Dr. A.D. Pathak, Director of the Institute during May 27-June 4 and September 7-8, 2020 to review and

the Institute. Sixty-two scientists and one technical officer (Annexure-1) of the Institute participated and discussed the research findings of 73 ongoing-Institute research projects, and the technical programme for the next year. First time, the IRC meeting was conducted online through MS teams to avoid physical contact as per Covid-19 management protocol issues by Govt. of India as precautionary measures.

Following new research project proposals/ concept notes were discussed and approved:

- Investigation of differentially expressing sugarcane proteins during red rot infection in susceptible and tolerant cultivars
- Population improvement and development of genetic stocks for high sugar accumulation potential
- Enhancing water productivity of sugarcane production system by regulating irrigation regimes and field moisture management
- Isolation, identification and pathogenicity of wilt pathogen in sugarcane
- Ergonomic evaluation of tools and equipment for drudgery reduction in sugarcane cultivation
- Development of e-powered multipurpose equipment adapted to controlled traffic farming for sugarcane
- International sugar trade and export opportunities for Indian sweeteners
- A study of IOT and Artificial Intelligence (AI) enablers in sugarcane farming system

Institute Management Committee Meeting

Forty seventh and forty eight meeting of the Institute Management Committee (IMC) were held under the chairmanship of Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow on February 18 and June 17, 2020. Progress of R&D efforts was reviewed and various administrative matters were discussed in the meeting.

CHAPTER 19

Participation in Seminars/Webinars/Symposia/Conferences *etc.*

Name	Seminar/Webinar/Symposium/Conference	Venue/Organizer	Date
Dr. A.K. Sharma	User's Workshop on "ICAR-KRISHI Geoportal – Challenges and Way Forward"	ICAR-National Bureau of Soil Survey and Land Use Planning, Nagpur	January 1-10, 2020
Dr. S.I. Anwar	107th Indian Science Congress	UAS, Bengaluru	January 03-07, 2020
Dr. S.I. Anwar	54th Annual Convention and International Symposium of Indian Society of Agricultural Engineers	Hotel Regency, Pune	January 07-09, 2020
All the Scientists of the Institute	National Seminar on Nanotechnology Applications in Sugarcane	ICAR-IISR, Lucknow	January 10, 2020
Dr. Sanjeev Kumar (Plant Breeding)	Zonal Breeders Meet-2020' of NW, NC&NE and EC Zones of AICRP (S)	Navsari Agriculture University, Navsari	January 10, 2020
Dr A.K. Mall	Advances and Innovations in Agriculture & Allied Sciences (AIAAS-2020)	New Delhi	January 31 – February 1, 2020
Drs. L.S. Gangwar S.N. Sushil, M. Swapna, Om Prakash and Sh. Brahm Prakash	2nd International Conference and Exhibition on Sustainability – Innovation & Diversification in Sugar and Allied Industry	VSI, Pune	January 31 – February 1, 2020
Drs. S.I. Anwar, M.K. Singh and Sukhbir Singh	National Conference on "Sustainable Environment & Climate" SOLARIS 2020	SRM University, Lucknow	February .07-09, 2020
Dr. A.K. Singh	Annual Workshop of AICRP on Farm Implements and Machinery (Online Mode)	ICAR-CIAE, Bhopal	February 23-25, 2021
Drs. A.K. Singh and S.I. Anwar	Annual Workshop of Agri Innovation Foundation	ICAR-IISR, Lucknow	February 27, 2020
All the Scientists of the Institute	Meeting organized on the occasion of National Science Day	ICAR-IISR, Lucknow	February 28, 2002
Dr. A. Chandra	IMC Meeting of ICAR-NIPB New Delhi	ICAR-NIPB, New Delhi	March 3, 2020
Dr. Sangeeta Srivastava	"Impact of Covid 19 on Indian Sugar Industry	National Sugar Institute, Kanpur	April 29, 2020
Dr. Y.E. Thora t	Meeting of 5th Scientific Advisory committee (SAC)	KVK, Dahigaon-Ne, Ahmednagar	May 4, 2020
Dr. A.K. Dubey	Technology dissemination to KVKs to boost horticulture sector	IISR, Lucknow	May 12, 2020
Dr. Sangeeta Srivastava	Domestic and Industrial Sanitization Amidst Pandemic	National Sugar Institute, Kanpur, India & Christ Church College, Kanpur	May 14, 2020

Name	Seminars/Webinars/Symposium/Conference	Venue/Organizer	Date
Drs. Sangeeta Srivastava, Sanjeev Kumar (Biotech) and A.K. Mall	Next Generation Genomics and Integrated Breeding for Crop Improvement (VII-NGGIBCI) on Genomics for Food, Health and Nutrition	Centre of Excellence in Genomics & Systems Biology (CEGSB), ICRISAT, Hyderabad	May 14, 2020
Dr. P.K. Singh	General Meeting of ICAR Seed Project	ICAR	May 14-15, 2020.
Dr. Sangeeta Srivastava	Challenges and Strategies for Agriculture, Health & Educational Services during Covid-19 in India	Society of Biological Sciences & Rural Development (SBSRD), Prayagraj (U.P.)	May 22, 2020.
Drs. C.K. Gupta and Rajeev Kumar	Desert Locust Management: Current Status & Future Strategies	ICAR-IARI, New Delhi	May 30, 2020
Dr. A. Chandra	IMC Meeting of ICAR-SBI, Coimbatore	ICAR-SBI, Coimbatore	June 1, 2020
Dr. A.K. Sharma	Online Meeting of Experts on ICAR-KRISHI Geoportal Spatial Data Infrastructure and Applications-A Way Forward	ICAR-NBSS&LUP, Nagpur	June 2, 2020
Dr. Sangeeta Srivastava	Exploiting Lignocellosic Feedstocks for Lignin and Chemicals	NSI, Kanpur	June 4, 2020
Dr. R. Gupta	International Webinar on Pandemic Covid- 19: Challenges in Global Environment	Navyug Kanya Mahavidyalaya, Lucknow	June 5, 2020
Drs. Radha Jain, Sangeeta Srivastava and C.K. Gupta	Webinar on "Ecology is Stable Economy"	NAHEP (ICAR)-CAAST, IARI, New Delhi	June 5, 2020
Dr. Radha Jain	Programme on World Environment Day	Doon University, Dehradun	June 5, 2020
Dr. R. Gupta	National Webinar on Climate Change and Agroforestry – Impacts, Implications and Strategies	CSAUA&T, Kanpur	June 5, 2020
Dr. Sangeeta Srivastava	An Environmental Agenda for the Future"	CSE, New Delhi	June 5, 2020
Dr. Amaresh Chandra	Meeting of NAAS	NAAS, New Delhi.	June 5, 2020
Dr. Sangeeta Srivastava	Perspectives of Health, Hygiene, Sanitation, Immunity & Social Distancing with Digital Media as per Current Scenario of COVID-19	Prof. Rajendra Singh University, Prayagaraj	June 05-06, 2020
Dr. Sangeeta Srivastava	Pandemics and Hunger Mainstreaming Millets for Addressing Food and Nutritional Security	SKRAU, Bikaner	June 8, 2020
Dr. A.K. Sharma	Meeting of ICAR Core Committee constituted for Preparation of Policy Document on Futuristic Crop Planning 2030 and 2050	ICAR-IIFSR, Modipuram, Meerut	June 10, 2020

Name	Seminars/Webinars/Symposium/Conference	Venue/Organizer	Date
All the Scientists of the Institute	Webinar on "Sugarcane Sector in Post COVID – 19 and Way Forward	ICAR-IISR, Lucknow	June 12, 2020
Dr. Sangeeta Srivastava	Genetics and Plant Breeding Research in Post COVID-19 Era"	Ch. Charan Singh University, Meerut	June 13-14, 2020
Dr. Sangeeta Srivastava	Monsoon 2020 Prediction and Strategies for Agriculture and Allied Sector in the Context of COVID -19	UPCAR, Lucknow	June 14, 2020
Dr. A.K. Mall	Priorities and Strategies to Boost Farmers Income	UPCAR and IISR, Lucknow	June 14, 2020
Dr. Sangeeta Srivastava	The Sugar Market & Consumptions under COVID-19 delivered by Peter De Klerk, Senior Economist, International Sugar Organization	NSI, Kanpur	June 16, 2020
Drs. Rajendra Gupta Radha Jain and V.P.Jaiswal	Entrepreneurship in Post COVID-19 for Enhancing Farm Income	Mewar University, Chittorgarh	June 17, 2020
Dr. S.R. Singh	International Education in Covid Times	Network 18	June 19, 2020
Dr A.K. Mall	Locust and Man	Mother Teresa College of Agriculture and All India Agricultural Students Association, Tamil Nadu	June 24, 2020
All Scientists of the Institute	Combating Post-COVID-19 Challenges in Sugarcane Sector: Appropriate Technologies and Approaches	ICAR-IISR, Lucknow	June 25, 2020
Dr. Radha Jain	International Training on Recent Physio-molecular Digital Tools	NAHEP-CAAST, DFSRDA, VNMKV, Parbhani	June 29-July 3, 2020
Dr. S.K. Goswami	International Webinar on Genomic Data Analysis and Tools	Bharathiar University, Coimbatore	June 30, 2020
Dr. R. Gupta	Research Article Writing and Publishing in Good Impact Journal	The National University of Malaysia	June 3, 2020
Drs. Vivekanand Singh and Veenika Singh	Hortipreneurship development in Uttar Pradesh		July 4, 2020
Drs. A.D. Pathak and V.P.Jaiswal	Future of Sugarcane in India	*Akhil Bharti Vidyarthi Parishad*, Lucknow & *Agrivision*	July 06, 2020
Dr. Pushpa Singh	Lessons from Covid-19 for Sustainable Development	Florafuna Foundation, Lucknow	July 11, 2020
Dr. A.K. Dubey and Sh. Ram Lakhan	ICAR Foundation Day	ICAR, New Delhi	July 16, 2020
Dr. Sangeeta Srivastava	Hackathon: Resources Conservation in Agriculture	SKN Agriculture University, Jobner	July 16, 2020

Name	Seminars/Webinars/Symposium/Conference	Venue/Organizer	Date
Drs. Sangeeta Srivastava and M. Swapna	The Impact of COVID-19 on The Sustainability of Sugarcane Industry Worldwide	ISSCT & Bonsucro, Brazil	July 20-, 2020
Dr. A.K. Mall	Can India solve its farmers plight & become food bowl of the World?	Biotechnika Info Labs Pvt Ltd.	July 22, 2020
Dr. A.K. Sharma	15th Meeting of Sugar Industry Sectional Committee (FAD 2)	Bureau of Indian Standards, New Delhi	July 22, 2020
Dr. A.K. Dubey and Sh. Ram Lakhan	Farmers Producers Organization for Better Future	CISCO Webex Platform	July 22, 2020
Dr. Radha Jain	Achieving Land Degradation Neutrality	Indian Association of Soil and Water Conservations (IASWC), Dehradun	July 22- 24, 2020
Drs. Radha Jain and Sangeeta Srivastava	Pandemic Novel Corona Virus Disease 2019 (Covid-19): The Unseen and Unsaid	CSIR -NBRI, Lucknow	July 24, 2020
Dr. Sangeeta Srivastava	Impact of Physio-Biochemical Research on Indian Agriculture	BAU, Sabour, Bhagalpur	July 28 2020
Dr. P.K. Singh	Breeding of Oilseeds: A Challenge for Self-sufficiency	BAU, Sabour, Bhagalpur	July 29, 2020
Dr. Radha Jain	Biotechnology for Crop Improvement	College of Agricultural Biotechnology, Ahmednagar	July 29-30, 2020
Dr S.K. Goswami	Forecasting and Disease Management	MEZ, IPS	August 4, 2020
Dr. A.K. Mall	Opportunities Challenges in Biotechnology	Milind College of Science, Aurangabad	August 04, 2020
Dr S.K. Goswami	Current Approaches and Tools for Microbiome Profiling	Bangalore	August 6, 2020
Drs. A.K. Singh, and Rajendra Gupta	Sugar and Sweeteners-Quality and Consumption Pattern	National Sugar Institute, Kanpur	August 06, 2020
Dr. V.P. Jaiswal	Underutilized Crops for Augmenting Farmers Income in Abiotic Stress Regions		August 10, 2020
Drs. T.K. Srivastava, Arun Baitha, V.P. Jaiswal and Pushpa Singh	Climate Resilient Agriculture: Adaptations and Strategies for Sustainable Production	College of Agriculture, Agriculture University, Kota	August 11, 2020
Dr. A.K. Mall	Present Status of Protection of Plant Varieties and Farmers' Rights Act 2001 (PPVFRA) & Commercialization of Varieties Registered under PPVFRA 2001	MPKV, Rahuri	August 11, 2020

Name	Seminars/Webinars/Symposium/Conference	Venue/Organizer	Date
Dr. S.K. Goswami	Bioinformatics Analysis on Soil Microbial Community Sequence Data Confirmation	ICAR-IARI, New Delhi	August 12-13, 2020
All Scientists	In-migrants Livelihood in Farm and Sugarcane Sector	ICAR-IISR, Lucknow,	August 13, 2020
Dr. T.K. Srivastava	National Webinar on Technological Options for Soil and Water Resource Conservation and Management	BSNV PG College, Lucknow.	August 16, 2020.
Drs. T.K. Srivastava and Pushpa Singh	Approaches for Resource Conservation and Management for Environmental Sustainability	Academy of Natural Resource Conservation and Management, Lucknow	August 16-17, 2020
Drs. T.K. Srivastava and S.K. Goswami	Mitigation and Adaptation Strategies for Alleviating Impact of Climate Change on Food Security	BSNV PG College, (KKV), Lucknow.	August 16, 2020
Drs. A. K. Dubey, R.K. Singh and Sh. Ram Lakhan	Workshop on Fodder & Livestock based Farming System Approach for Livelihood Improvement of SC Farmers	ICAR-IGFRI, Jhansi	August 17-18, 2020
Dr. S.I. Anwar	Training Programme for ABI Centres under NAIF Scheme of ICAR	ICAR-NAARM, Hyderabad	August 17-19, 2020
Dr. M. Swapna	2nd BIOEN-Research Webinar on Bio-fuels Technologies: The Sustainability Challenge	FAPESP, Sao Paulo, Brazil	August 20, 2020
Drs. T.K. Srivastava, Pushpa Singh, Rajendra Gupta, Sukhbir Singh	Mitigation and Adaptation Strategies for Alleviating Impact of Climate Change on Food Security	B.S.N.V. P.G. College (KKV), Lucknow	August 25, 2020
Dr. A.K. Dubey and Sh. Ram Lakhan	Fostering Freshwater Aquaculture Technology Dissemination through KVK Network	ICAR	August 27, 2020
Dr. A.K. Singh	Mid -Term Review of AICRP on Farm Implements and Machinery	ICAR-CIAE, Bhopal	September 8-10, 2020
Dr. Radha Jain	Drone Remote Sensing in Agriculture	The Indian Society of Agro-physics	September 9, 2020
Drs. T.K. Srivastava and Pushpa Singh	Resource Management and Biodiversity Conservation to Achieve Sustainable Development Goals		September 11-12, 2020
Dr Deeksha Joshi	A Session on Accessing	Taylor and Francis Group	September 15, 2020
Dr. C.K. Gupta	*Ozone Parat Ksharan: Vartmaan Sthiti Aur Bhavishya Kee Chunautiyan*	CESCRA, IARI, New Delhi	September 16, 2020
Dr. Deeksha Joshi	Climate Smart Integrated Farming System"	ICAR-NIASM, Baramati	September 18, 2020

Name	Seminars/Webinars/Symposium/Conference	Venue/Organizer	Date
Drs. Sangeeta Srivastava, M. Swapna and Sanjeev Kumar (Agri. Biotech.)	Regulation and Genome Edited Plants (A series of 5 webinars)	ICRISAT, Hyderabad,	Sept. 22, 29, Oct. 06, 13, 20, 2020
Drs. Pushpa Singh and Deeksha Joshi	National Webinar on Management of Biotic and Abiotic Stresses in Protected Agriculture	CSK-HPKVV, Palampur	September 22-24, 2020
Dr. D.N. Borase	Issues related to commercialization of Microbe-based Product	ICAR- NBAIM, Mau	September 24, 2020
Dr. D.N. Borase	6th Scientific Advisory Committee (SAC) of *Krishi Vigyan Kendra*	KVK- Dahigaon-Ne, Ahmednagar	September 25, 2020
All Scientists of the Institute	J Gate@CeRA Webinar on Effective Utilization (eResource Platform)	ICAR-IISR, Lucknow	September 25, 2020
All Scientists of the Institute	Webinar on *Vigyan Sanchar Mein Rajbhasha Hindi ka Mahatv*	ICAR-IISR, Lucknow	September 26, 2020
Drs. Radha Jain, A.K. Sharma, L.S. Gangwar, S.R. Singh, R.R. Verma and Mr. Brahm Prakash	Webinar on "Farm Bill 2020: Understanding the Implications"	NAHEP-CAAST, ICAR-IARI, New Delhi	September 26, 2020
Dr. V.P. Jaiswal	Contract Farming	Press Information Bureau , Govt. .of India, Lucknow	September 29, 2020
Dr. Sangeeta Srivastava	State Level Consultation on India's 5th "Science, Technology, and Innovation Policy (STIP)-2020"	UPCST, Lucknow	September 29, 2020
Dr. Sanjeev Kumar (Plant Breeding)	'Gandhian Philosophy in the Backdrop of Agricultural Transformation'	ICAR-SBI, Coimbatore	September 30, 2020
Dr. C.K. Gupta	International Webinar on 'Soil spectroscopy: An Emerging Technique for Rapid Soil Health Assessment	ICAR-IISS, Bhopal, India and World Agroforestry, Narobi, Kenya	October 01, 2020
All Scientists of the Institute	*Aatma Nirbhar Bharat aur Vigyan: Gandhi Jayanti Par Punravalokan*	ICAR-IISR, Lucknow	October 01, 2020
Dr. V.P.Singh	Sugarcane Research and Extension and Advisory Committee Meeting"	SRI, RPCAU, Pusa, Samastipur	October 01, 2020
Dr. P.K. Singh	DUS Data Management	PPV&FRA, New Delhi	October 6-7, 2020
Dr A.K. Mall	Geospatial Approaches for Agricultural Water Management		October 7-9, 2020
Dr. A.K. Mall	Omics in Agriculture		October 7-9, 2020
Dr. C.K. Gupta	Translating Physiology into Techniques for Abiotic Stress Tolerance	Indian Society of Plant Physiology and ICAR-NIASM, Baramati	October 9, 2020

Name	Seminars/Webinars/Symposium/Conference	Venue/Organizer	Date
Drs. A.D. Pathak, M.R. Singh, Radha Jain, Sangeeta Srivastava, S.K. Shukla, A. Chandra, S.N. Sushil, L.S. Gangwar and Pushpa Singh	Indo-Brazil Meeting	ICAR-IISR, Lucknow	October 13, 2020
Dr. Amaresh Chandra	Management of Waterlogged Sodic Soils for Livelihood Security of Resource Poor Farmers	ICAR-CISH, Lucknow	October 13, 2020
Dr. R.K. Singh	Workshop of IGFRI-NIAFTA	ICAR-IGFRI, Jhansi	October 13-15, 2020
All Scientists of the Institute	33rd Biennial Workshop of AICRP on Sugarcane	ICAR-IISR, Lucknow	October 19-20, 2020
Dr. A.K. Dubey	National Webinar on Mushroom Production		October 19-23, 2020
Dr. A. Chandra	Innovation, Excellence Indicator Meeting	Confederation of Indian Industry, New Delhi	October 20, 2020
Dr. Radha Jain	Genomics Strategies for Improvement of Abiotic Stress Tolerance in Crop Plants	ICAR-NAISM, Baramati	November 27, 2020
Dr. V.P. Singh	Stakeholders Dialogue on Weed Management	ISWS and TAAS	December 9, 2020
Dr. A.K. Dubey	Mid-Term Workshop of KVKs of ATARI, Kanpur	ICAR-ATARI, Kanpur	December 10-11, 2020
All Scientists of the Institute	RAC Meeting	ICAR-IISR, Lucknow	December 15, 2020
Dr. Deepak Rai	Review Workshop of KVK Activities	ICAR-ATARI, Kanpur	December 15, 2020
Dr A.K. Mall	International Webinar on Genome Editing to Enhance Multiple Disease Resistance in Crop plants	Plant Genomia	December 20, 2020
Dr A.K. Mall	Webinar on Advances in Post- harvest Management of Fruits and Vegetables	Dhanalakshmi Srinivasan Agriculture College, Tamil Nadu	December 24, 2020
All Scientists of the Institute	Hindi Workshop on Negativity to Positivity	ICAR-IISR, Lucknow	December 28, 2020
Dr. Rajeev Kumar	Modern Interventions in Environmental Management	ICAR-IIAB, Ranchi	December 30, 2020
Dr. R.K. Singh	Workshop of IGFRI-NIAFTA	ICAR-IGFRI, Jhansi	December 30, 2020

Chapter 20

Events organized

Institution establishment ceremonies

Hon'ble Union Minister of Agriculture and Farmers Welfare lays the Foundation Stone of KVK, Lakhimpur Kheri-II of ICAR-IISR, Lucknow

Shri Narendra Singh Tomer, Hon'ble Minister of Agriculture and Farmers Welfare, Rural Development and Panchayati Raj, Govt. of India laid the foundation stone of Krishi Vigyan Kendra at Lakhimpur Kheri (U.P.). This KVKs has been sanctioned as the second KVK of the district. Speaking on the occasion, the Union Minister highlighted the need of linking the farmers with the technology for accruing the benefits of farm research being conducted at various

institutions. He urged the Scientists of KVKs to encourage FPOs in their area to help organize the farmers to enhance their capacities and be instrumental in delivering the special package fund announced for infrastructural development of various sectors of the agriculture by the Hon'ble Prime Minister. Lakhimpur Kheri being the largest district of Uttar Pradesh and having about 70% of the total cultivated area under sugarcane and nine sugar mills,

the KVK will act as mouthpiece of the IISR for transferring the latest production technology as well as improved varieties for the benefits of the farmers. Sh. Kailash Choudhary, Hon'ble Minister of State for Agriculture and Farmers Welfare, Govt. of India appreciated the efforts of KVKs located across the country for enhancing the income of the farmers and urged the farmers to work for *Atmanirbhar Bharat* by organizing FPOs.

Sh. Surya Pratap Shahi, Hon'ble Minister of Agriculture, Agriculture Education and Agricultural Research, Govt. of Uttar Pradesh congratulated the Hon'ble Prime Minister and Union Agriculture Minister for sanctioning second KVK for Lakhimpur Kheri. Sh. Shahi expressed his confidence that the farmers of Lakhimpur Kheri will be benefitted by the KVK established under the administrative control of ICAR-IISR, Lucknow in the form of improved varieties with matching agro-technologies. Sh. Ajay Mishra 'Teni', Hon'ble Member of Parliament, Lakhimpur Kheri and Sh. Adala Prabhakara Reddy, Hon'ble Member of Parliament, Nellore also addressed on the occasion.

Dr. Trilochan Mohapatra, Secretary, DARE and DG, ICAR welcomed the Chief Guest, Guests of Honours and other dignitaries, and expressed the hope that the income of the farmers of the area will also be doubled by following the integrated planning and strategy at the KVK level, using IISR Model of Doubling Farmers Income. Dr. A.K. Singh, DDG (Agricultural Extension), ICAR. New Delhi proposed the vote of thanks to all the Guests and dignitaries. The programme was coordinated and conducted by Dr. A.D. Pathak, Director, ICAR-Indian Institute of Sugarcane Research, Lucknow. Large number of ICAR Officers including Dr. T.R. Sharma, DDG (CS), ICAR;

Dr. B.N. Tripathi, DDG (AS), ICAR; Dr. R.K. Singh, ADG (CC), ICAR; Dr. V.P. Chahal, ADG (Ag. Extension), ICAR; Dr. Y.G. Prasad, Director, ICAR-ATARI, Hyderabad; Dr. Attar Singh, Director, ICAR-ATARI, Kanpur and Dr. D. Damodar Reddy, Director, ICAR-CTRI, Rajahmundry participated in the function.

69th Foundation Day of the Institute celebrated

ICAR-IISR, Lucknow celebrated its 69th Foundation Day on February 16, 2020 which marked the successful journey of 68th glorious years of sugarcane research since the establishment of the Institute in the year 1952. Prof. Archana Shukla, Director, IIM, Lucknow was the Chief Guest on the occasion. While the programme was presided by Dr. Sushil Solomon, Ex. VC, CSAUA&T, Kanpur. Prof. Archana Shukla congratulated IISR for its outstanding contributions which has culminated in the highest ever sugarcane and sugar production and applauded the IISR partnership with industries for commercialization

of the technology. Giving the Inaugural address on Management issues of research organizations with special reference to team spirit and leadership, Prof. Shukla highlighted the need of technical skills, inter-personal skills and strategic skills for team building which is the pre-requisite for achieving any mission. She also emphasized on energy, excitement and passion on the part of every employee of the organization to own the pride of the achievements. Dr. A.D. Pathak, Director, ICAR-IISR delivered the welcome address and highlighted the achievements made during the last year. Dr. Pathak informed that the two varieties of sugarcane *viz.*, CoLk 12207 and CoLk 12209 developed by the Institute have been released during last year. Under outreach programme the Institute was able to bring the adoption of seed production technology, intercropping and ratoon management technique in more than 15,500 hectares

area with an estimated additional benefit of ₹ 190 crores to the farmers in one single year. Presiding over the function, Dr. Sushil Solomon urged the scientists to address the issue of sustainability for sugarcane and sugar production. Dr. Solomon highlighted the need to address the issues of varietal planning, ethanol blending with petrol, more economic and diversified uses of bagasse, intercropping for doubling the farmers income, taking breeder seed production programme in a big way in other states of the country also.

On this occasion, 16 employees of the Institute were honoured with the Excellence Award in various categories. The Best Scientist Award was conferred to Dr. A.K. Sah, Principal Scientist, Extension and Training, while Dr. Lalan Sharma was honoured with the Best Young Scientist Award. The best team award was conferred to SWAPAM Lab. The Best Worker Awards of other categories were conferred to Sh. Brahm Prakash, Dr. Deepak Rai, Sh. C.P. Prajapati, Shri Abhay Kumar Srivastava, Shri Sant Ram, Shri Rajendra Kumar, Sh. Avadhesh Kumar Verma, Shri Arvind Yadav, Smt. Shiv Devi Maurya and Dr. Varucha Misra. Three innovative farmers *viz.*, Sh. C.S. Tiwari of Narsinghpur (M.P.), Sh. Awadhesh Kumar Verma of Sitapur and Shri Mukesh Kumar of Lucknow (U.P.) were also honoured with Innovative Farmer Awards. Dr. T.K. Srivastava, Principal Scientist also delivered a talk on "Conservation of water resources in climate change perspective" during Open Platform on Water Conservation. Young researchers also gave innovative ideas to conserve water for the environmental security. The sugarcane seed of one improved variety of sugarcane *viz.*, CoLk 11206 was also distributed to participating sugarcane farmers. Dr. D.R. Malaviya, Head, Division of Crop Improvement proposed the vote of thanks. The programme was conducted by Dr. Anita Sawnani. A *Kisan Goshthi* and exhibition was also organized on this occasion which was attended by large number of innovative farmers of Lucknow and Sitapur districts of Uttar Pradesh.

Seminars and Workshops

A Brainstorming Session on Nanotechnology Application in Sugarcane organized

ICAR-IISR, Lucknow organized a brainstorming session on "Nanotechnology Applications in Sugarcane" on Jan 10, 2020 under the chairmanship of Prof. A.N. Mukhopadhyay, Ex-Vice-Chancellor, AAU, Jorhat. The session started with opening remarks of Dr. A.D Pathak, Director ICAR-IISR, Lucknow, who highlighted the importance of Nanotechnology Applications in Indian agriculture with special reference to sugarcane. Prof. A.N. Mukhopadhyay, expressed his views on implications of nano-materials in agriculture and emphasised that similar brainstorming sessions on other burning topics were need of the hour. Dr. J.C. Tarafdar, UGC & ICAR Emeritus Scientist; Dr Tapan Adhikari, Principal Scientist, ICAR-IISS, Bhopal; Dr Biplab Sarkar, Senior Scientist, ICAR-IIAB, Ranchi and Dr. M. Sajid Khan, Professor, Integral University, Lucknow presented their talks on nanotechnology applications in

agriculture, their synthesis and characterization. Of the four status papers, the first presentation was given by Dr. J.C. Tarafdar. He strongly vocalised that nanomaterial could serve to be an as an alternate technology to precisely detect and deliver the correct quantity of nutrients required by crops in suitable proportion that promote productivity while ensuring environmental safety. He also suggested that balanced fertilization may be achieved through nanotechnology. He described the impact of nano-fertilizer products on physiological, biochemical, nutritional and morphological changes in plants and the fate of nano-products in soil and plant systems. In addition, he described his explorations on the effects of nano-fertilizer products on rhizosphere microorganisms and bio-geocycling of nutrients under natural field conditions. The Session was attended by four distinguished invited speakers, working extensively with nano-materials from states of Rajasthan, Madhya Pradesh, Jharkhand and Uttar Pradesh, four representatives from IFFCO from New Delhi and Lucknow, participants from Sugarcane Research Institute, Bihar; U.P. Council of Sugarcane Research, Shahjahanpur and Scientists from ICAR-IISR, Lucknow.

Workshop on Promoting and Recognizing Agri-Innovations in Uttar Pradesh organized

A one-day Workshop on Promoting and Recognizing Agri-Innovations in Uttar Pradesh was jointly organized by Agri-Innovation Foundation (AIF), Lucknow and ICAR-IISR, Lucknow on February 27, 2020. Inaugurating the Workshop, Dr. Birendra Singh, Director General, UPCSR, Lucknow and VC, NDUA&T, Faizabad highlighted that agriculture has become an industry with maximum potential and impact that would be a gateway of opportunities for inclusion of various stakeholders within and around the ecosystem, where in agriculture has become the guiding pillar for economic transformation in the country representing a space where innovation can

serve the marginalized in diverse ways. Giving a brief introduction about the theme of the Workshop, Dr. Bangali Baboo, Ex. National Director NAIP, ICAR, New Delhi and President, AIF called for involving all stakeholders including farmers, input supplier, processors, policy makers besides scientists in solving a defined problem.

On this occasion, Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow; Dr. S. Rajan, Director, ICAR-CISH, Lucknow; Dr. V.K. Mishra, Head, ICAR-CSSRI RC, Lucknow; Dr. S.K. Pandey, Ex. Director, ICAR-CPRI, Shimla and Er. Neeraj Srivastava, Deputy Director (Agriculture), Uttar Pradesh also addressed the audience and highlighted the need of developing innovations in the field of agriculture which will help the farmers of the Uttar Pradesh in fulfilling the PM's ambitious desire to double the farmers income by the year 2022. It was suggested by various speakers that a

widely evolving technological landscape is an outset of new possibilities to target and price credit, to share the risk and to harness information technology to enhance farm productivity which generates both welfare and regional economic integration as it contributes more than 15% to the national GDP which determines the standard of living for more than 60% of the Indian population, directly or indirectly dependent on agriculture. The Workshop highlighted the need to look for the strategic places where policy and investment can help to improve outcomes for agricultural households. On this occasion, Dr. R.C. Srivastava, VC, RPCAU, Pusa, Samastipur; Dr. R.K. Vishwakarma, Principal Scientist, ICAR-CIPHET, Ludhiana; Dr. Neelima Garg, Principal Scientist, ICAR-CISH, Lucknow; Dr. Niranjan Prasad, Pr. Scientist & Head, ICAR-IINRG, Ranchi; Er. P.R. Chaurasia, Ex. Chief Engineer, Minor Irrigation, Govt. of Uttar Pradesh; Dr. S.P. Singh, Principal Scientist, ICAR-IARI, New Delhi; Dr. R.K. Singh, SMS (Animal Science), KVK, ICAR-IISR, Lucknow were awarded Fellow Award. Four innovative farmers *viz.*, Sh. Jai Singh of Bahraich; Sh. Ramesh Verma, Smt. Bitana Devi and Sh. Brijesh Verma of Lucknow were also conferred with Agri-Innovators Award for their outstanding contributions in the field of sugarcane, exotic vegetable, milk production and bee keeping & honey production. All the awardees acquainted the audience about their contribution in their respective fields.

Webinar on Sugarcane Sector in Post COVID-19 and Way Forward organized

A webinar on the topic Sugarcane Sector in Post COVID-19 and Way Forward was organized at ICAR-IISR, Lucknow on June 12, 2020. The basic objective of the webinar was to provide common platform to researchers, industry executives, managers and government officials to discuss and analyze the distress in sugarcane sector of Sub-tropical India in COVID-19 time; and to decide future course of actions for addressing current distress and challenges. The panellists of the webinar were Dr. S. Solomon, Ex. VC, CSAUA&T, Kanpur; Dr. A.D. Pathak, Director, IISR, Lucknow; Prof. Narendra Mohan, Director, National Sugar Institute, Kanpur; Shri Roshan Lal Tamak, Executive Director & CEO, Sugar Business, DCM Shriram; Shri V.K. Shukla, Additional Cane Commissioner, Govt. of Uttar Pradesh; Dr. A. Chandra and Dr. Sudhir Shukla, IISR, Lucknow. The session was attended by more than 100 participants from sugar industry, research institutes and Govt. cane department.

Dr. A.D. Pathak shared his views on emerging challenges in sugarcane Research & Development to address issues in post COVID era. Prof. Narendra Mohan elaborated and discussed in detail on the topic

'Reorienting technological approach for process and product diversification to mitigate corona crisis'. Prof. Mohan appealed the industry executives to revisit the sugar mills during off season to decide revised standard operating procedure in the wake of Corona crisis. Shri Roshan Lal Tamak in his presentation touched upon all the issues related to sugar industry perspectives encompassing factory operations, marketing, hygiene, farmers' livelihood, digitalization *etc*. Shri V.K. Shukla presented the government initiatives taken during COVID-19 pandemic and future strategy for smooth sailing of the industry in the state. The scientists of the Institute Dr. A. Chandra, Dr. Sudhir Kumar Shukla and Dr. A.K. Sah presented some issues related to sugarcane crop.

Webinar on Employment Opportunities in Sugarcane and Agriculture for Migrant Labour Organized

Webinar on Employment Opportunities in Sugarcane and Agriculture for Migrant Labour was organized on August 13, 2020. Speaking as the Chief Guest of the Webinar Shri Sanjay R. Bhoosreddy, the Cane and Sugar Commissioner and Additional Chief Secretary, Govt. of U.P. highlighted various programme launched by the Cane and Sugar Department in view of large number of unemployment in post Covid era. At the outset, Dr. A.D, Pathak, Director, ICAR-IISR, Lucknow welcome the guest and participants and presented sugarcane and sugar production scenario of U.P. and India. Dr. Pathak appreciated the efforts of Sugar Industries in smooth functioning of sugar mills in the lockdown period and congratulate the sugar industry in producing sufficient quantities of sanitizer for protecting the mass from Covid-19. The programme was coordinated by Dr. A.K. Sah, Principal Scientist and Incharge, Extension and Training Unit. About 100 participants across the nation participated in the Webinar.

Webinar on *"Aatmnirbhar Bharat Aur Vigyaan: Gandhi Jayanti Par Punravlokan"* organized

Webinar on *"Aatmnirbhar Bharat Aur Vigyaan: Gandhi Jayanti Par Punravlokan"* was organized jointly by IISR, Lucknow and District Rajbhasha Implementation Committee (Office-3). Dr. Manoj Kumar Pateria, Consultant and Head, National Council of Science and Technology Communication, New Delhi was the Chief Speaker on this occasion.

Women Farmers' Seminar organized

In order to celebrate Nutrition Month- 2020, a Women Farmers' Seminar and Training on Balanced Nutrition Management was organized by Krishi Vigyan Kendra, ICAR-IISR, Lucknow on September 17, 2020 in Gram Panchayat, Meerkhnagar, Mohanlalganj, District, Lucknow. Inaugurating the programme as the chief guest, Dr. A.D. Pathak, Director, IISR, Lucknow said that we all should use the available land around our homes as a nutritious garden which facilitates us to get more and more fresh and agro-chemical free vegetables and fruits round the year. Dr. Pathak threw light on the role of a balanced diet of nutrients found in vegetables and fruits for boosting the immunity of the human body during the period of the Corona pandemic. Dr. S.N. Singh, Nodal Officer, KVK, IISR, Lucknow said that we can produce and consume fresh fruits and vegetables from our nutritious garden by utilizing our spare time and benefit financially also. Dr. Singh further added that farm women can maintain good health by keeping all the members of the family especially children away from malnutrition. Dr. Veenika Singh trained the *Anganwadi* workers and women farmers present in the programme on the importance of nutritious garden. In this programme, 43 *Anganwadi* workers of all the development blocks of Lucknow district and 70 women farmers and housewives of the area were present. On this occasion, Mr. A.N. Singh, DGM (Marketing) from IFFCO, Lucknow distributed seed kits for nutritious garden to women farmers and *Anganwadi* workers. Dr. A.K. Dubey, Head, KVK, Lucknow gave introductory address and proposed vote of thanks.

Workshop on Roof Top Kitchen Gardening

A Workshop on "Roof Top Kitchen Gardening: An Initiative" – cum - Farmers Fair was organized by KVK, ICAR- IISR, Lucknow on January 28, 2020. Inaugurating the Workshop-cum-Farmers Fair, Mrs. Sanyukta Bhatia, Mayor, Lucknow said that the inclusion of vegetables in our diet is extremely important for healthy and disease free life, as the

vegetables not only protect our body from diseases, but also an abundant source of vitamins, minerals and other nutrients which are essential for good nutrition. Mrs. Bhatia further added that the rural people are migrating to the urban areas, leading to increase in the urban population besides, increasing pollution.

Dr. A.D. Pathak, Director, IISR highlighted the achievements made by KVK, Lucknow on roof top kitchen gardening in urban areas and suggested that KVK should be given more emphasis on roof top gardening. Dr. S.N. Singh, Principal Scientist & Nodal Officer, KVK, Lucknow highlighted the purpose of organizing this awareness programme for urban

women. Dr. Singh said that apart from roof top kitchen gardening, the unutilized land in urban areas surrounding their houses can also be used as per the requirement of vegetables and fruits. Sh. Indramani Tripathi, Nagar Ayukt and Shri Prabhunath Rai, President, Bhojpuri Samaj were also present on the occasion. The programme was attended by more than 500 urban and rural women.

National Compaigns and Missions

National Science Day celebrated

National Science Day was celebrated on 28th February, 2020 at ICAR-IISR, Lucknow. The programme was initiated with a welcome note by Dr. Pushpa Singh, Principal Scientist and Organising

Secretary followed by a documentary on "An Echo from the Past", reflecting memoir and contributions of Dr. C.V. Raman in the field of science. Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow highlighted the glimpses of modern science and enlightened the participants on the occasion. A lecture on "Next Generation Sugarcane Genomics – Peculiarities and Challenges" was delivered by Dr. Sanjeev Kumar, Principal Scientist (Plant Biotechnology). Keeping in view, the theme area of the year, Women in Science, a satellite talk by Dr. Jocelyn Bell Burnell, Visiting Professor, Astrophysics, University of Oxford and a Fellow of Mansfield College, Birmingham, UK on "Contentious Brass Tacks -Women in Science" was played. Dr. Deeksha Joshi, Principal Scientist (Plant Pathology) unveiled the past and present status of women in science across the globe. She also threw light on endeavours and accomplishments of women in science and the barriers they have faced during their journey over the years of scientific evolution in her talk entitled "Women in Science -Mirroring Contributions".

Republic Day

The 71st Republic Day was celebrated at ICAR-IISR, Lucknow on January 26, 2020 with pomp and show, great zeal and spirit. The national flag was unfurled by Dr. A.D. Pathak, Director of the Institute, amidst loud cheers. The National Anthem was sung by all the persons present there. Speaking on the occasion, Dr. Pathak highlighted the significance of the day and

immense contribution made by the freedom fighters for the country. Dr. Pathak also narrated about the significant achievements of the Institute for the last year. Dr. Pathak also congratulated the scientists for their outstanding contributions made for the sugar sector of India. All the buildings of the Institute were also decorated and illuminated.

Independence Day

The ICAR-IISR, Lucknow celebrated the 74th

Independence Day on 15th August 2020 with great pride, patriotic fervour and enthusiasm, as India got its freedom from the centuries-old colonial rule on August 15, 1947. At the outset, Dr. A.D. Pathak, Director of the Institute along with 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, followed by recitation of the National Anthem by the Scientists, Officers and Staff of the Institute. Dr. Pathak urged upon all the participants to realize, understand and 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.

Constitution Day Celebration

As per direction of the Council, Constitution Day was celebrated on November 26, 2020 at ICAR–IISR,

Lucknow to commemorate the adoption of the Constitution of India and to honour & acknowledge the contribution of the Founding Fathers of the Constitution. All the officials of the Institute joined in the reading of the 'Preamble' to the Constitution, led by Hon'ble President of India at 11.00 AM on November 26, 2020.

Vigilance Awareness Week – 2020

The Vigilance Awareness Week-2020 was celebrated at the Institute during October 27-November 2, 2020 with the theme '*Satark Bharat, Samriddh Bharat*' (Vigilant India, Prosperous India). The observance of the Vigilance Awareness Week-2020 was commenced with the Integrity Pledge administered virtually by Dr. A.D. Pathak, Director of the Institute. Speaking on the occasion, Dr. Pathak asked all the officials to perform their official duties in time bound and transparent manner which will be a great contribution towards the progress of the nation.

Appreciating the good work being done by the Institute, Dr. Pathak urged the officials to join hands to fight against corruption by adopting honesty as the life style.

Swachchhta Fortnight celebrated

ICAR-Indian Institute of Sugarcane Research, Lucknow celebrated *Swachchhta* Fortnight and Covid-19 proper behaviour campaign was celebrated during December 16-31, 2020. On December 16,2020, Dr. A.D. Pathak, Director, ICAR-IISR administered the *Swachchhta* Pledge to all the officers and employees of the Institute while inaugurating the *Swachchhta Pakhwada*, quoting Mahatma Gandhi. On this occasion, all the scientists, technical, administrative, skilled supporting staff and other staff of the Institute took the oath of cleanliness. During this fortnight, apart from various buildings of the Institute, the employees of the Institute spread the message of cleanliness to the people by doing *shramdaan* in the nearby localities, villages and public places. Along with this, some competitions and *Nukkad Natak* were also organized. On December 17, 2020, chairing the meeting of Scientific Advisory Panel of KVK-IISR, Lucknow, Dr. A.D. Pathak, Director, ICAR-IISR requested all the staff to spread the message of cleanliness and to maintain appropriate behaviour in view of COVID-19. He requested all the participants to make the general public aware that we should not be complacent in fighting COVID-19. The messages of regular hand wash from soap/sanitizers, use of masks and to maintain two yards spacing between two people was spread. The Scientists and staff visited various localities of Lucknow and informed the residents of the locality about the importance of cleanliness, particularly in such a harsh environment of COVID-19. The public was acquainted about the harmful effects of dirty atmosphere which causes several diseases among the human. The people who were not using face masks and moving on the streets were informed about the ill effects of their behaviour. They were requested to regularly wash their hands with soap or sanitize them.

use face masks and to maintain two yard spacing. The stickers depicting message of cleanliness and not using single use plastic were displayed at several places and distributed to the general public in nearby areas of the Institute.

National Unity Day observed

In pursuance to Endorsement F.No.15-3/2020-CDN dated October 27, 2020 by the Council, ICAR-IISR, Lucknow observed National Unity Day on the occasion of birth anniversary of Sardar Vallabhbhai Patel on October 27, 2020. On this occasion, a pledge was taken on that day by all the officials of the Institute. The observance of the National Unity Day was commenced with the Integrity Pledge administered virtually by Dr. A.D. Pathak, Director of the Institute. On this occasion, Dr. A.D. Pathak, Director narrated the contributions of First Home Minister of the country, Late Sardar Vallabhbhai Patel for the unity and integrity of the country as his efforts towards national integration led him to be referred to as the 'Iron Man of India'. He urged the officials to strive together to achieve the goal of unity and integrity and consolidate India against the attacks on its unity, integrity, and sovereignty.

International *Yoga* Day observed

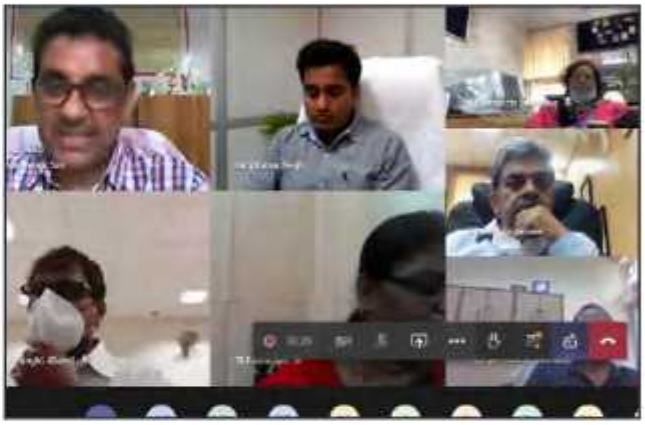
Yoga is a physical, mental and spiritual practice that originated in India and describes a way of life. *Yoga* is not just about exercise and relaxation, but also about discovering understanding and identifying yourself. The ICAR-IISR, Lucknow celebrated the 6th International Day of *Yoga* on June 21, 2020 with the theme *Yoga* at Home and *Yoga* with Family announced by the Ministry of AYUSH, Government of India. 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.

Strengthening of *Rajbhasha*

Hindi Workshops organized

Four Hindi workshops were organised during the year. First Hindi Workshop of the year 2020 was organised on March 3-5, 2020. Forty-one Scientists, Officers and Staff participated in the Hindi Workshop. Second Hindi Workshop of the year 2020 was organised on June 29, 2020 which was attended by 34 Officers and Staff of the Institute. In this workshop, Mr. Saroj Kumar Singh, Senior Administrative Officer of the Institute delivered a lecture on the topic "e-office". Third Hindi Workshop of the year 2020 was organized on September 24, 2020 which was participated by 55 Scientists, Officers and other staff. In this workshop,

Dr. R.M. Singh, Medical Officer, IISR Dispensary delivered a lecture on the topic "Prevention from COVID". Fourth Hindi Workshop of the year 2020 was



held on December 28, 2020 which was attended by 100 trainees. In this Workshop, Mr. Sanjay Kumar Singh, Director, Dimensions Education, New Delhi delivered a lecture on the topic "From negativity to positivity".

Hindi Pakhwada organized

Hindi Pakhwada was organized at the Institute during September 14-30, 2020. The fortnight was started on September 14, 2020 with a lecture on the topic "Importance of Official Language Hindi in Science Communication". During this fortnight, several competitions like Typing in Unicode, Circular writing, Debate, Review of Hindi work done throughout the year, writing competition for Ikshu on the topic "Contribution of agriculture sector in self-reliant India" programmes were organized in the Institute. All the competitions were organized online during the fortnight. About 130 Scientists, Officers and other staff of the Institute participated in the above-mentioned competitions. Certificates and Cash Prize for first, second, third and consolation prizes in various competitions were distributed in the Prize Distribution Ceremony organized on September 30, 2020.

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

ICAR-IISR, Lucknow is the chairman office of District *Rajbhasha* Implementation Committee (Office-3). At present, there are 70 offices of Central Government Offices located in Lucknow under Office-3 for evaluation of work related with *Rajbhasha*. Two meetings of the year 2020 were organized under the

chairmanship of Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow and Chairman, District *Rajbhasha* Implementation Committee in which the Heads of the Member Offices participated in the meeting. First half yearly meeting of District *Rajbhasha* Implementation Committee (Office-3) for the year 2020 was organized on August 24, 2020 in online mode. The Office Heads of Office-3 and Sh. Ajay Malik from Department of Official Language, Ministry of Home, Govt. of India participated in the meeting. Ten organizations/ Departments were awarded for their excellent work in Hindi in the meeting. The Second half yearly meeting of District *Rajbhasha* Implementation Committee (Office-3) for the year 2020 was organized on November 11, 2020 in online mode. The Office Heads of Office-3 and Sh. Ajay Malik from Department of Official Language, Ministry of Home, Govt. of India participated in the meeting. Ten organizations/ Departments were awarded for their excellent work in Hindi in the meeting.

Parthenium Awareness Week

Parthenium hysterophorus, locally called carrot weed, *gajar ghas* or Congress grass, and the most problematic alien invasive weed has spread alarmingly in cropped, non-cropped and forest area and invaded millions of hectares of land throughout the country. In view of the seriousness and magnitude

of the threat posed by this weed, the Institute organized a "*Parthenium* Awareness Week" during August 16-22, 2020 by involving both the KVKs located at Lucknow and Lakhimpur Kheri. All the Scientists and staff joined in the campaign and uprooted *Parthenium* weeds in and around Institute campus and farm.

Other events

Establishment of mango orchard at KVK, Lucknow

An orchard of mango was established at KVK, IISR, Lucknow on August 18, 2020. Seven varieties of mango *viz.*, Ambika, Arunika, Mallika, Aamrapali, Dasheri, Chausa and Langda were planted in the orchard. Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow inaugrated the programme by planting a mango sapling on this occasion. Dr. Pathak expressed his hope that that the farmers of the Lucknow district will get benefits for a long period through this KVK orchard as the improved technology package will be demonstrated to the farmers through this orchard. Dr. S.N. Singh, Nodal Officer. KVK and Dr A.K. Dubey, Senior Scientist and Head, KVK, IISR, Lucknow also shared their views on the occasion.

CHAPTER 21

Distinguished visitors

Name of the distinguished visitor	Date of visit
Dr. A.K. Vasisht, ADG (PIM), ICAR, New Delhi	January 1, 2020
Prof. P.K. Srivastava, Ex. Dean, CAU, Imphal	January 3, 2020
Dr. A.N. Mukhopadhyaya, Ex. Vice Chancellor, AAU, Jorhat	January 10, 2020
Dr. M.S. Chauhan, Director, CIRG, Makhdoom,Mathura	January 10, 2020
Dr. R.K. Mittal, Vice-Chancellor, SVBPUAT, Modipuram, Meerut	January 17, February 14, March 3 and October 28, 2020
Dr. J.P. Mishra, ADG (PIM), ICAR, New Delhi	January 17, 2020
Dr. B. Singh, Director General, UPCAR, Lucknow	January 23-24, 2020
Prof. S.V. Dwivedi, Dean, College of Horticulture, BUAT, Banda	
Dr. Panjab Singh, Ex. Secretary DARE & Director General, ICAR, New Delhi	January 23 and February 19, 2020
Mrs. Sanyukta Bhatia, Mayor, Lucknow	January 28, 2020
Dr. D.R. Singh, Director, ICAR-NRC on Orchid, Pakyong, Gangtok	January 29, 2020
Dr. S.K. Chakrabarti, Director, ICAR-CPRI, Shimla	January 29, 2020
Prof. G.K. Singh, Vice- Chancellor, DUVASU, Mathura	February 13, 2020
Dr. U.S. Gautam, Vice-Chancellor, BUAT, Banda	February 14, 2020
Prof. Archana Shukla, Director, IIM, Lucknow	February 16, 2020
Dr. Sushil Solomon, Ex. Vice Chancellor, CSAUA&T, Kanpur	February 16, 2020
Dr. B. Singh, Director General, UP Council of Agricultural Research, Lucknow	February 27, 2020
Dr. S. Rajan, Director, ICAR-CISG, Lucknow	February 27, 2020
Dr. R.C. Srivastava, Vice Chancellor, Dr. RPCAU, Pusa, Samastipur	February 27, 2020
Dr. Bangali Baboo, Ex. Director, NIAP, New Delhi	February 27, 2020
Dr. S.K. Pandey, Ex. Director, ICAR-CPRI, Shimla	February 27, 2020
Dr. V.K. Misra, Head, ICAR-CSSRI RS, Lucknow	February 27, 2020
Sh. Radha Mohan Singh, Ex. Minister of Agriculture and Farmers' Welfare, Govt. of India	June 29, 2020
Dr. B.R. singh, Registrar,SVPBUA&T, Meerut	October 9, 2020
Dr. S.K. Dwivedi, Ex. Director, ICAR-NRC on Equines, Hisar	November 24, 2020
Dr. O.N. Singh, Vice-Chancelor, Birsa Agriculture University, Kanke, Ranchi	November 27, 2020
Dr. K.K. Kumar, Ex. Director, NRC on Litchi, Muzaffarpur	December 18 and 24, 2020
Dr. A.S. Panwar, Director, ICAR-IIFSR, Modipuram, Meerut	December 27, 2020
Dr. S.K. Singh, Director, ICAR-DKMA, Pusa, New Delhi	December 31, 2020
Dr. B. Singh, Vice-Chancellor, ANDUA&T, Kumarganj, Faizabad	December 31, 2020

CHAPTER 22

Personnel

(As on December 31, 2020)

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

Scientist (Plant Pathology)	:	Dr. Sanjay Kumar Goswami
Scientist (Plant Pathology)	:	Dr. Chandramani Raj
Scientist (Plant Pathology)	:	Dr. Shweta Singh
Chief Technical Officer	:	Dr. D.C. Rajak (On deputation)
Senior Technical Officer	:	Smt. Pramila 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
Senior Scientist (FMP)	:	Dr. Sukhbir Singh
Scientist (LWME)	:	Ms. 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. Suresh Kumar Kushwaha
Assistant Chief Technical Officer	:	Mr. Krishna Nand Singh
Technical Officer	:	Mr. Chaman Singh
Plant Physiology & Biochemistry		
Principal Scientist & Head	:	Dr. Radha Jain
Principal Scientist (Biochemistry)	:	Dr. Amaresh Chandra
Principal Scientist (Organic Chemistry)	:	Dr. Pushpa Singh
Principal Scientist (Plant Physiology)	:	Dr. S.P. Singh
Scientist (Plant Physiology)	:	Dr. Chandan Kumar Gupta
Scientist (Biochemistry)	:	Mr. Rajeev Kumar
Assistant Chief Technical Officer	:	Mr. C.P. Singh
Technical Officer	:	Mr. R.K. Singh
PME Cell & Institute Technology Management Unit		
Principal Scientist & Incharge	:	Dr. L.S. Gangwar
Chief Technical Officer	:	Mr. Brahm Prakash
Chief Technical Officer	:	Dr. Anita Sawnani
AKMU		
Principal Scientist & Incharge	:	Dr. Rajesh Kumar
Principal Scientist (Agril. Economics)		Dr. A.K. Sharma
Principal Scientist (Computer Application)	:	Dr. S.S. Hasan
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
Assistant Chief Technical Officer	:	Mr. A.K. Singh
Juice Lab		
Principal Scientist & Incharge	:	Dr. S.P. Singh
Assistant Chief Technical Officer		Mrs. Meena Nigam

AICRP on Sugarcane		
Project Coordinator	:	Dr. A.D. Pathak
Principal Scientist (Entomology)	:	Dr. Arun Baitha
Principal Scientist (Agronomy)	:	Dr. S.K. Shukla
Scientist (Agronomy)	:	Dr. Sanjai Yadav
Scientist (Plant Pathology)	:	Dr. Lalan Sharma
Chief Technical Officer	:	Dr. G.K. Singh
Assistant Chief Technical Officer	:	Mr. Adil Zubair
HRD Cell		
Nodel Officer	:	Dr. Sangeeta Srivastava
Co-Nodel Officer	:	Dr. Sukhbir Singh
Nodal Officer, EFC (Commercial Crops), ICAR	:	Dr. Sangeeta Srivastava
Farm Section		
Principal Scientist & In-charge	:	Dr. S.K. Shukla
Farm Managar (Chief Technical Officer)	:	Dr. B.B. Joshi
Krishi Vigyan Kendra, Lucknow		
Senior Scientist & I/c	:	Dr. Akhilesh Kumar Dubey
SMS (Home Science)	:	Dr. (Smt.) Veenika Singh
SMS (Plant Protection)	:	Dr. Deepak Rai
SMS (Animal Science)	:	Dr. Rakesh Kumar Singh
SMS (Horticulture)	:	Dr. Viveka Nand Singh
Farm Manager	:	Mr. Deep Kumar
Krishi Vigyan Kendra-II, Lakhimpur Kheri		
Principal Scientist	:	Dr. Niranjan Lal
SMS (Horticulture)	:	Sh. A.D. Deepak Misra
SMS (Plant Protection)	:	Dr. Vivek Kumar
SMS (Agronomy)	:	Sh. Sanjay Kumar Pandey
Farm Manager	:	Sh. S.K. Singh
Rajbhasha Prakoshtha		
Principal Scientist & In-charge	:	Dr. A.K. Sah
Technical Officer	:	Mr. Abhishek Kumar Singh
Art & Photography		
Principal Scientist & In-Charge	:	Dr. L.S. Gangwar
Chief Technical Officer	:	Mr. Vipin Dhawan
Chief Technical Officer	:	Mr. Y.M. Singh
Assistant Chief Technical Officer	:	Mr. Avadhesh Kumar Yadav
Library		
Principal Scientist & In-Charge	:	Dr. (Mrs.) Sharmila Roy
Assistant Chief Technical Officer	:	Mr. Ghanshyam Ram
Senior Technical Officer	:	Mr. R.N.P. Bharti
In-Charge, Seed Production Unit	:	Dr. Sanjeev Kumar
In-Charge, Vehicle	:	Mr. Raj Kumar
In-Charge, Landscaping	:	Mr. Rajiv Ranjan Rai
In-Charge, Guest House	:	Mr. A.K. Sharma
Manager, Guest House	:	Mr. Nag Chand
IISR Regional Centre, Motipur (Bihar)		
Principal Scientist & In-charge	:	Dr. A.K. Mall
IISR Biological Control Centre, Pravarnagar (Maharashtra)		
Principal Scientist & Nodal Officer	:	Dr. S.N. Singh

Scientist (Microbiology)	:	Dr. D.N. Borase
Scientist (Nematology)	:	Mr. Yogesh Thorat
Administration		
Senior Administrative Officer	:	Mr. S.K. Singh
Administrative Officer	:	Mr. A.K. Sharma
Finance & Accounts Officer	:	Mr. Raja Ram
Assistant Administrative Officer	:	Mr. R.K. Yadav
	:	Mr. V.P. Tiwari
	:	Mr. Nag Chandra
	:	Mr. Prashant Kamal Srivastava
Private Secretary	:	Mr. Rajeev Arora
	:	Mr. Prem Chandra
Security Officer	:	Mr. C.P. Prajapati

Appointment

Name of official	Post held	Date of Joining
Mr. V.A. Blessy	Scientist (Land and Water Management Engineering)	January 7, 2020
Dr. Rajesh Uttareshwar Modi	Scientist (Farm Machinery and Power)	January 7, 2020
Mr. Aalok Shiv	Scientist (Genetics & Plant Breeding)	January 7, 2020
Ms. Manisha Saini	Scientist (Genetics & Plant Breeding)	January 7, 2020
Mr. Nenavath Krishna Kumar Rathod	Scientist (Genetics & Plant Breeding)	January 7, 2020

Promotions

Name of official	Present position	Promoted to	w.e.f.
Shri Dharmendra Singh	SSS	Technician (T-1)	21.12.2020
Shri Kulpreet Singh,	T-1	T-2	07.09.2015
Shri Kuldeep	T-1	T-2	12.11.2015
Sh Kapil Dev Pandey	T-1	T-2	16.10.2019
ShTaruk Nath Saini	UDC	Assistant	01.08.2020
Smt. Manju Srivastava	T-1	T-2	16.10.2019
Sh Ajay Prakash	T-1	T-2	16.10.2019
Sh Raja Ram	T-1	T-2	16.10.2019
ShMaikuKanaujia,	T-1	T-2	16.10.2019
Sh Yogesh Mohan Singh	ACTO	CTO	25.06.2017
Sh Avadhesh Kumar Yadav	STO	ACTO	01.04.2017
Sh Sunil Kumar Mishra	STO	ACTO	21.04.2017
Sh Umesh Kumar	STO	ACTO	18.08.2017
Dr. Rakesh K. Singh	T-6	T 7-8	13.03.2017

Transfers

Name and Post	From	To	Date of Joining at IISR
Scientists			
Dr. S.K. Holker	ICAR-IISR BCC, Pravaranagar	ICAR-NRC on Grapes, Pune	December 29, 2020
Dr. Chandramani Raj	ICAR Research Complex on NEH Region, Umiam	ICAR-IISR, Lucknow	October 24, 2020
Dr. Shweta Singh	ICAR Research Complex on NEH Region, Umiam	ICAR-IISR, Lucknow	October 24, 2020

Superannuation

Name of official	Post held	Date of retirement
Dr. S.K. Duttamajumder	Principal Scientist (Plant Pathology)	January 31, 2020
Sh. Anand Mohan Srivastava	Assistant Administrative Officer	January 31, 2020
Sh. Sudhir Kumar	Senior Technician	January 31, 2020
Sh. Nageshwar Lal	Assistant	February 29, 2020
Sh. Lalit Prasad Singh	Lower Division Clerk	February 29, 2020
Dr. D.R. Malaviya	Principal Scientist	June 30, 2020
Sh. Shardan and Srivastava	Technical Officer	May 31, 2020
Sh. Dildar Hussain	Technical Asstt.	June 30, 2020
Sh. Raj Nath Sharma	Technician	June 30, 2020
Sh. Indra Pal Maurya	Asstt. Chief Technical Officer	September 30, 2020
Sh. Surya Deo Singh	Asstt. Chief Technical Officer	October 31, 2020
Dr. S.K. Awasthi	Chief Technical Officer	October 31, 2020
Sh. Devendra Singh	Chief Technical Officer	November 30, 2020
Mrs. Shiv Devi	Skilled Support Staff	December 31, 2020

Obituary

Name of official	Post held	Date of death
Mr. Umesh Kumar	Senior Technical Officer	December 02, 2020

CHAPTER 23

Meteorological Data

Important weather parameters during January 2020 to December 2020 at ICAR- Indian Institute of Sugarcane Research, Lucknow

Month	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Rainy days (No.)	Bright sunshine hours (hrs./day)	Evaporation (mm/day)	Wind speed (km/hr)
	Maximum	Minimum	at 7: 18 am	at 2:18 pm					
January 2020	19.6	8.2	95.7	65.5	84.6	4	4.7	1.1	2.5
February 2020	24.5	8.8	92.0	45.9	9.2	2	7.8	2.4	2.8
March 2020	28.8	15.2	88.0	46.8	47.8	4	8.2	3.7	3.9
April 2020	35.5	19.5	76.2	31.8	14.0	2	9.3	5.8	3.2
May 2020	37.4	22.8	73.6	39.6	79.8	5	9.1	6.4	2.8
June 2020	34.4	25.4	86.7	65.5	52.2	8	5.7	3.9	2.2
July 2020	34.2	24.6	88.6	71.0	417.6	14	5.1	4.5	2.3
August 2020	33.8	26.0	92.2	72.6	269.3	9	5.9	3.2	2.4
September 2020	35.0	25.5	91.4	62.7	159.2	6	6.3	3.4	2.1
October 2020	34.3	18.3	94.4	39.7	0.0	0	7.6	3.0	1.2
November 2020	28.4	10.8	93.9	37.4	32.0	1	6.9	2.1	1.4
December 2020	23.7	7.3	92.8	45.3	0.0	0	5.6	1.3	1.5

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