भाकृअनुप
ICAR

भारतीय गन्ना अनुसंधान संस्थान, लखनऊ
ISO 9001:2015

Annual Report

2017-18

ICAR-Indian Institute of Sugarcane Research, Lucknow

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Preface

It gives me immense pleasure to present the Annual Report of ICAR – Indian Institute of Sugarcane Research, Lucknow comprising the research and developmental activities undertaken by the Institute during the year 2017-18. During this period, India has witnessed the highest ever sugar production of 32 million tonnes. Uttar Pradesh has also created history by producing 12.05 million tonnes of sugar, surpassing the sugar production level of 8.77 million tonnes achieved last season (2016-17). This was possible only by the concerted efforts of the research Institute, and efforts of various State cane development departments. Sugarcane productivity and sugar recovery has improved significantly in U.P. during last three sugar seasons. However, the labour scarcity, input cost escalation, surplus sugar production and escalating cane price arrear on sugar mills due to prevailing low sugar prices are some issues which still needs to be addressed. Utilization of advance sugar processing technologies with higher efficiencies in the integrated sugar-energy complexes has also improved sugar recovery.

To harness the potential of sugarcane sector towards doubling farmers' income, ICAR-IISR has initiated a joint project with DCM Shriram Limited (DSL), New Delhi in Public Private Partnership mode in command areas of four sugar mills in the year 2017. The basic objective of the project is to double income of all 2028 farm families in eight villages of two districts by introducing technological, and development interventions as well as interventions in allied agri enterprises like dairying, animal husbandry, poultry, fish farming, apiculture, rural entrepreneurship development etc. The positive impact of the project is quite apparent as income from sugarcane has increased to ₹ 2.25 lakh/ha in 2017-18 from ₹ 1.10 lakh/ha in base year 2015-16.

This period was very fruitful for sugarcane varietal improvement at IISR. CoLk 09204 (Ikshu-3), a mid-late, high yielding sugarcane variety was recommended for release by the CVRC for its cultivation in the North West Zone. Two other sugarcane varieties, viz., CoLk 11203 (early maturing) and CoLk 11206 (mid-late) were also identified by the Varietal Identification Committee of the All India Coordinated Research Project on Sugarcane for notification and release.

IISR has focused on development of new machines for sugarcane cultivation and has developed many sugarcane machines and prototypes. Recently, a prototype of cane node planter was developed. A single row manual multicrop planter was also designed and developed for sowing intercrops in sugarcane. Two models of sugarcane stripper-cum-detopper were designed, developed and tested. Refinement in sugarcane cleaner-cum-washer for jaggery with capacity of 210 kg/h cane was done.

The studies conducted to assess the impact of IISR technologies in sustaining sugarcane production in India revealed that the monetary contribution of the sugarcane cutter planter due to labour saving alone was estimated to be Rs. 150 crores per year. The Institute is also imparting training to UG/PG students along with capacity building of the farmers and cane developmental workers.

Our painstaking journey during this year was suitably rewarded by number of awards, bestowed to the Institute. *Rajbhasha Patrika "Ikshu"* bagged *Rajbhasha Kirti Puraskar* (First Prize) by *Rajbhasha Vibhag*, Ministry of Home, Govt. of India and *Ganesh Shankar Vidhyarthi Puraskar* (First Prize) by ICAR for the year 2016-17. ICAR-IISR has received Mahindra Samriddhi India Agri Award 2018 for Public Sector Research Organization. ICAR-IISR has also bagged the Best KVK (Zonal) Award of *Pandit Deendayal Upadhyay Rashtriya Krishi Vigyan Protsahan Puraskar*-2017 from the Hon'ble Prime Minister of India. Numbers of prestigious awards were also conferred to the Institute Scientists for their outstanding contributions in their field.

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. J.S. Sandhu and Dr. Anand Kumar Singh, Deputy Director Generals (Crop Science) and Dr. R.K. Singh, Assistant Director General (CC), ICAR which I acknowledge with sincere gratitude and reverence.

I would like to appreciate Drs. M.R. Singh, Radha Jain, D.R. Malaviya, V.P. Singh and A.K.Singh, all Heads of Divisions, and Drs. S.K. Shukla, Rajesh Kumar, S.N. Singh, A.K. Sah and A.K. Mall for their sincere efforts in compiling and editing the report of their respective Divisions/Sections/Units. The sincere efforts of Dr. S.K. Duttamajumder, Dr. L.S. Gangwar, Dr. A.K. Sharma, Sh. Brahm Prakash, Smt. Anita Sawnani, Sh. Atul Kumar Sachan, Dr. Y.P. Singh, Sh. Ashish Singh Yadav and Dr. M. Ashfaque in compiling, editing and timely bringing out the report are highly appreciated.

(A.D. Pathak)
Director

Date : June 30, 2018

Contents

Executive Summary

Crop Improvement

- CoLk 09204 (Ikshu-3), a high yielding mid-late maturing sugarcane variety, was recommended for release by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties for its commercial cultivation in the North West Zone vide its notification No. S.O. 1379(E) dated March 27, 2018.
- Two sugarcane varieties, viz., CoLk 11203 (early maturing) and CoLk 11206 (mid-late maturing) were identified by the Varietal Identification Committee of the All India Coordinated Research Project on Sugarcane for their notification and release.
- Two early maturing (CoLk 17201, CoLk 17202) and one mid-late maturing sugarcane clone (CoLk 17204) were accepted by AICRP(S) for multi-location testing in the North West Zone.
- LG 05817, a sugarcane clone having durable resistance to red rot was submitted for registration as a novel genotype.
- Two promising clones, viz., LG 13825 and LG 13821 having moderate resistance (MR) to three pathotypes, viz., Cf 01, Cf 08 and Cf 09 of red rot, more than 17% sucrose, and >91 t/ha cane yield were promoted to station trial. In addition, three promising clones, LG 11406, LG 13430 and LG 12429 for high sugar were included in the station trial.
- Two high sugar genetic stocks (LG 09487 and LG 09475) with 18-19% sucrose content were sent to NHG at ICAR-SBI, Coimbatore for use as parental clones.
- The Institute is maintaining a collection of 350 genotypes consisting of 30 species level genotypes (*Saccharum officinarum*, *S. barberi*, *S. sinense*), 51 ISH and IkshuISH clones, 71 LG selections, 173 commercial hybrids, and 25 somaclonal variants.
- Chromosome number variability studies in a sugarcane genotype CoLk 8102 and clonal populations of CoLk 8102 (GC) revealed that the variation in somatic chromosome number gradually narrowed down in consecutive clonal generations (C_1 to C_3).
- RNA seq data was generated from parents (MS 68/47 and CoV 92102) and their high and low sucrose F_1 bulks. Differential gene expression, indels and alternate splicing events were identified between the two parental lines and further confirmed in the two bulks for the unigenes predominantly involved in ion trans-membrane transport, glucose metabolic process and small molecule biosynthetic process.
- The genotype Khakai (*S. sinense*) was multiplied under *in vitro* conditions, and slow growth cultures were developed. Stored cultures were able to regenerate even after a period of 360 days. Similarly, *in vitro* cultures were also established for three newly released varieties, viz., CoLk 09204, CoLk 11203 and CoLk 11206.
- In DBT-Accredited Test Laboratory (ATL), 500 samples of sugarcane and 905 samples of banana were tested for virus indexing and genetic fidelity testing for batch certification. Virus indexing for mother stock was done for 170 samples of sugarcane and 915 samples of banana.
- Approximately ~9500 q and 27,000 q of seed cane was produced at ICAR-IISR, Lucknow, U.P. and Bihar under Bihar Seed Project, respectively. These seed cane were distributed to farmers/sugar mills for further multiplication.

Crop Production

- The findings on sugarcane productivity in relation to initial soil organic carbon content and nutrient management revealed that above 0.65% level of initial soil organic carbon content at the time of planting (in February-March) exerts significant influence on cane yield and sustains in the ratoon crop.
- The growing of sugarcane in waterlogged conditions had no apparent effect on soil pH and EC. The soil organic carbon content, available N, available P, microbial biomass carbon, microbial biomass nitrogen, microbial counts (TCB, TCA and AZO) and enzymatic activities (DHA, ACP and ALP) were the highest in RDF under optimum conditions. However, available K, sulphur, total cultivable fungi (TCF) and FDHA were the highest in FP under WL conditions.
- Among all the sugarcane growing systems, sub-optimal condition had the worst effect on cane yield followed by waterlogging. Significantly higher average cane yield (89.3 t/ha) was recorded in RDF under optimum conditions followed by RDF (80.6 t/ha) under waterlogging. The imbalance mineral fertilization (FP) practices under waterlogging conditions had the worst

effect on cane yield followed by optimum and sub-optimum and decreased cane yield by about 34.7, 32.8 and 24.3%, respectively over RDF.

- The microbial biomass nitrogen, alkaline phosphatse, *Azotobacter* counts, available nitrogen, sulphur, and soil organic carbon were identified as soil quality indicators. Available N was the highest contributor (14.5%) towards the soil quality development and was followed by *Azotobacter* counts (12.4%) > MBC (12.2%) > ALP (10.9%) > Pav. (10.2%) > SOC (9.40%) > available S (8.97%).
- Rice-wheat cropping system recorded a mean organic carbon content of 0.36% as compared to sugarcane based cropping system (0.43%) in 0-30 cm depth of soil. It decreased in 30-60 cm depth (0.24%). Mean available nutrient status in soil decreased as compared to initial status. Higher wheat yield (46.9 q/ha) was recorded in sugarcane based cropping system after harvest of ratoon crop as compared to 35.9 q/ha in rice-wheat system. Residue retention with *Trichoderma* in wheat improved the wheat yield by 11.2% in rice-wheat- based cropping system. However, trash mulching with *Trichoderma* in ratoon crop improved the cane yield by 9.5% as compared to mulching without *Trichoderma*
- Sugarcane-potato based cropping system improved the soil organic carbon from 0.59 to 0.66%. Intercropping of potato with sugarcane showed available N (218.15 kg/ha), available K_2O (281.76 kg/ha) available S (45.74 mg/kg) and available Zn (2.12 mg/kg) content as compared to potato-sugarcane sequential system. The maximum tuber (345.2 q/ha) and sugarcane yields (109.8 t/ha) were recorded with application of recommended NPK + Zinc and Sulphur equivalent to NPSZn. Similarly, the highest uptake of N, P, K, and S in sugarcane was registered with application of recommended NPK+S and Zn equivalent to NPSZn. Potato + Sugarcane intercropping system observed higher cane equivalent yield (129.4 t/ha), benefit cost ratio (2.65) and net income (2.54 lakh/ha) as compared to potato-sugarcane sequential system.
- Potassic fertilizers containing elemental sulphur appeared to be better than others for getting higher sugarcane cane and sugar yields. Potassium through sulphate of potash (SOP) recorded significantly higher plant cane yield being at par with potassium ammonium sulphate, MOP + Sulphur @ 40 kg/ha and slow release potash fertilizer in plant crop. However, higher ratoon crop yield (108.3 t/ha) recorded with potassium ammonium sulphate closely followed by slow release potash fertilizer (105.2 t/ha) and least by MOP + Sulphur @ 40 kg/ha (93.3 t/ha).
- The results of cane node technology indicated almost similar trend in respect to tillers and number of millable canes. On an average, the cane yield was 88.03 t/ha in cane node planting and was 8.75% higher than that of conventional method of planting (80.33 t/ha).
- Development of sugarcane based integrated farming system model including different components of agriculture viz. bee-keeping and intercropping systems was initiated for small farm holders, wherein allocation of farm land was done to meet minimum essential annual requirements of food and fodder of a household with seven family members and overall improvement in livelihood. The most profitable sugarcane, banana and papaya based intercropping systems were identified. Modules of bee-keeping and mushroom cultivation were developed.
- Studies on the biology of *Ipomoea* spp. showed that there was an intra plant competition under its variable density. Data recorded at different intervals on plant height, dry matter accumulation, root length was significantly affected at one or other stages of crop growth by both, density of species as well as depth of sowing. The intra plant competition (density *v/s* growth) is more visible than the depth of sowing. It is also revealed that *Ipomoea* could germinate, even if its seeds lying 10 cm below the soil layer.
- Sugarcane yield (114.3 t/ha) under paired-row trench planting with trash mulching was significantly higher than conventional flat method of planting with trash mulching (101.9 t/ha) owing to higher number of millable canes. The trash application had significant effect on sugarcane yield under different irrigation scheduling. However, irrigation schedules did not influence the cane yield significantly. The WUE was found maximum under paired-row trench planting with trash mulching (0.982 t/ha cm) followed by conventional flat method of planting with trash mulching (0.877 t/ha cm) and paired-row trench planting (0.845 t/ha cm).
- Among all early maturing promising sugarcane genotypes including zonal checks under test, CoLk 12203 gave maximum cane and sugar yield/ha due to higher tillering, NMC, girth and weight of single cane. However, it could not perform well particularly in respect to juice quality parameters viz, brix and sucrose content compared to the performance level of zonal checks (Co 0238 and CoJ 64).

- Genotype CoLk 12205 planted at 90 cm row spacing gave higher NMC over CoS 767 and CoS 8436. The highest cane yield was obtained in genotype CoPant 97222 planted at 90 cm spacing followed by CoLk 12205. At 12 month stage, the CCS (t/ ha) yield was statistically at par in CoPant 97222, CoLk 12205, CoS 12232, CoPant 1226 and CoH 12263 but was significantly superior to rest of the genotypes. 90 cm spacing was found more beneficial than planting at 120 cm row to row spacing.

Crop Protection

- Insect pests and disease surveys were conducted in command areas of different sugar mills in Uttar Pradesh, Bihar, Maharashtra and Narsinghpur district of Madhya Pradesh. The incidence of early shoot borer, root borer, top borer and army worm was 35, 60, 43, 5-10 per cent, respectively. A black beetle (*Heteronychus* sp.) was observed gnawing the basal portion of young shoots and causing dead heart. Incidence of other insect pests was low. Red rot was observed in Co 0238 at many locations. In Maharashtra, incidence of white grub and YLD showed an increasing trend.
- Both thermotherapy of two hours for three consecutive days at 50°C and standard MHAT were found effective to suppress the YLD upto 300 days of planting.
- Out of 56 genotypes, 11 genotypes were rated resistant (R), 35 were moderately resistant (MR) and rest 10 genotypes were susceptible (MS to HS) against the pathotype Cf 08. Twenty four genotypes were susceptible to smut. Fourteen genotypes were susceptible (S), rest 42 were resistant (R) to wilt.
- Different delivery methods of potential strains of *Trichoderma* were evaluated. Higher reduction in red rot incidence (52.9%) was recorded in sett treatment + single soil application of STr-108 at the time of planting.
- Incidence of borer pests of sugarcane was low in all the plots along with trap crops with corresponding increase in parasitisation.
- Isolates of Co 0238 have shown intermediate virulence against BO 91 but virulence to Co 62399 and CoS 8436. Thus, indicating the development of a new specific virulence (though it has lower spectrum of overall virulence) which is capable of knocking down the popular variety Co 0238.
- Fourty one early and mid late maturing Zonal varieties IVT, AVT I Plant & II plant were evaluated against red rot (Cf 08 and Cf 09), smut and wilt. In IVT (Early), Co 14034 and CoLk 14202 were resistant against Cf 08 and Cf 09. In AVT (Early)–I Plant, Co 13034 and CoPb 13181 were MR against Cf 08 and Cf 09. In AVT (Early)-II Plant, Co 12027 was resistant against both the pathotypes. In IVT (Mid late), out of 15 genotypes, CoLk 14205 was resistant (R) and thirteen genotypes were moderately resistant to both the pathotypes. In AVT (Mid late)-I Plant, Co 13035, CoH 13263, CoLk 13204, CoPant 13224 and CoPb 13182 were moderately resistant (MR) to both the pathotypes. In AVT (Mid-late)-II Plant, Co 12029, CoH 12263, CoLk 12205, and CoS 12232 were found moderately resistant to both the pathotypes. Fifteen genotypes were graded as resistant (R) against smut. Twelve genotypes were susceptible to wilt.
- Twenty seven genotypes were screened against red rot at IISR RC, Motipur. In IVT (Early), CoBln 14501, CoLk 14206, CoLk 14207, CoP 14436, CoP 14437, CoSe 14451 and CoSe 14453 were moderately resistant. In AVT (Early)-I Plant, CoSe 13452, in AVT (Early)-II Plant, CoLk 12207 and CoSe 12451 and in AVT (Mid late)-II Plant, CoLk 09204, CoLk 12209 and CoP 12438 were rated as resistant (R) to Cf 07 and Cf 08. Seventeen genotypes were rated as resistant (R) against smut. Incidence of wilt and YLD was observed in some genotypes.
- CoLk 12203 showed MS reaction and rest of the genotypes showed HS (Highly Susceptible) reaction to top borer. All the genotypes showed LS reaction to internode borer.
- Methodology for rearing black bug and its egg parasite has been developed.

Plant Physiology and Biochemistry

- An experiment conducted in autumn season using variety CoLk 94184 with four types of irrigation treatments. NMC and yield decreased by 7% and 17%, respectively in the treatment of 75% crop water requirement and 40% depletion of soil moisture as compared to 100% crop water requirement and 40% depletion after dipping in ethrel+ GA_3 spray.
- The priming of setts with 100 ppm NAA registered higher germination % than *Ethrel*. Maximum increase was in Co 0238 and minimum was in CoLk 94184. The proliferation of root was more with NAA treatment in Co 0238 compared with CoLk 94184. Root dry biomass was 3.5 times higher in Co 0238 than CoLk 94184.
- An experiment of PGRs (NAA, BAP, *Ethrel*) in both autumn and spring seasons indicated increase in

germination percentage with PGRs treatment. The highest increase was obtained in Ethrel treatment; 42% in autumn and 60% in spring planting.

- Twenty three sugarcane genotypes including six popular varieties (tolerant/susceptible) were evaluated for rooting pattern and root anatomy under waterlogged condition along with control. Results obtained indicated reduced shoot dry mass in most of genotypes except in CoLk 94184, CoLk 12204, CoLk 12206, LG 06605, LG 04439, D-6-13 and S 5085/11 due to waterlogging. Total root dry mass was relatively higher in waterlogged affected plants. Based on findings on root attributes, UP 9530, CoS 97264, LG 04439, LG 05020, D-6-13, S5085/11 and S 5087/11 were grouped as tolerant lines.
- On average mean basis, pH, Sucrose%, CCS%, Brix and S/R ratio showed gradual increase from Nov to Feb due to waterlogging. EC of juice and juice purity showed gradual increase from Nov'17 to Jan'18 and slight reduction in the month of Feb'18.
- Na, K, Ca contents were estimated in digested sample of dry leaf tissues of waterlogged affected sugarcane genotypes. Na ranged from 0.126-1.275%, K ranged from 0.375-2.363% and Ca ranged from 0.176-0.508%.
- An experiment was conducted to study the influence of soaking/foliar application of PGR and PGR + essential nutrients on growth and yield of sugarcane crop. Cane yield ranged from 83.31 to 106.76 t/ha; the highest cane yield 106.76 t/ha was obtained in control set with *Ethrel* + GA_3 + Kinetin spray followed by *Ethrel* set with *Ethrel* + Nutrient spray (102.45 t/ha) in plant crop. Cane yield ranged from 100.45 to 127.40 t/ha; the highest cane yield was obtained in *Ethrel* treated setts followed by *Ethrel* treated sett with *Ethrel* spray (126.44 t/ha) in ratoon crop.
- Priming of cane seed (Setts) with 100 ppm ethrel not only improved the germination but also hastened it by 15-20 days. GA_3 induced ~42.3% enlargement in cell size and about 39.3% increase in internodal length (sink capacity), 177% escalation in reducing sugar level (sink strength), amplified expression of sucrose metabolizing enzymes (sink demand) viz. 7.5 fold SAI, 4.5 fold CWI and 6 fold SPS. All these augmented more sucrose accumulation in the stalk.
- A significant positive correlation was found between sucrose % of source and sink tissues. It was greater in the top internode (R^2=0.679) than middle (R^2= 0.580) and bottom (R^2= 0.518) internodes depicting that sucrose content in stalk depends on the source efficiency to synthesize it.
- In transcriptomic study, the fold change indicated that the starch and sucrose metabolizing genes showed maximum fold change of 5.0 and 3.0 among top and bottom internodal samples, respectively. A homology match using Blastx analysis tool yielded 65 transcripts which were found to share homology with C_4 plants like *Saccharum, Sorghum* and *Zea mays*.
- Four promising varieties of sugarcane namely CoLk 94184, CoLk 09204, CoPK 05191 and Co 0238 were used and juice analysis was performed at different days taking samples from control and BKC+SMS treated canes. Post-harvest deterioration (after 7 days of cane harvest) in terms of sucrose % juice was minimum in CoPK 05191.

Agricultural Engineering

- Fertilizer dispensing system of the trench planter was redesigned and relocated for applying the fertilizer ahead and 3-5 cm deeper than the sett placement. Newly developed prototype was field tested.
- Developed tractor operated multipurpose tool frame was field tested with furrow opening, inter-row interculturing and intra-row herbicide spraying attachments.
- Prototypes of tractor operated two row disc type ratoon management device with and without stubble shaving attachments were field tested at IISR farm and at farmers field.
- Cane node planter was developed and seed metering mechanism was tested in the laboratory. Seed metering mechanism worked well in the actual field situation.
- A single row manual multicrop planter having PVC rotor was designed and developed for sowing intercrops in sugarcane.
- Two models of sugarcane stripper-cum-detopper were designed, developed and tested at IISR farm.
- Prototype feasibility testing of tractor operated BCS reaper binder was conducted at farmers' field.
- A total of 38 prototypes were fabricated in the workshop of Agricultural Engineering. Eleven prototypes (tractor operated-5, manually operated-6) were supplied to different locations for multi-location trials.
- FLDs of IISR deep furrow sugarcane cutter planter, RMD, trench planter and deep furrow sugarcane

cutter planter cum multicrop raised bed seeder were conducted.

- Refinement of sugarcane cleaner-cum-washer (210 kg/h cane) unit was capable of doing medium level cleaning.
- The highest irrigation water use efficiency (1631.3 kg/ha-cm) was recorded in ring-pit planting system and the lowest (506.1 kg/ha-cm) in surface irrigated crop planted at 90 cm spacing. Irrigation treatments and varieties both influenced sugarcane yield and irrigation water use efficiency (IWUE).

Extension and Training

- To address the problem of limited availability of healthy seed cane, the project on entrepreneurship development in seed cane production in PPP mode was implemented in Sitapur, Barabanki, Lakhimpur, Shravasti and Ballia districts of Uttar Pradesh. Seventy three seed cane plots in 28.84 ha area was maintained in 18 villages. Training session was organized to promote entrepreneurial ability of cane farmers in seed cane business.
- A total of 1696.90 t seed cane was produced with average cane yield of 111.43 t/ha (2016-17). The average net profit earned by farmers from seed cane crop was ₹ 2,81,827/ha, where as average net profit in normal cane sp. ranged between ₹ 80,000 and 1,20,000/ha.
- FLDs on intercropping of vegetable pea, potato, lentil, chickpea, maize, mustard, groundnut, pigeonpea with autumn and spring cane in farmers' fields covering 20 ha area in Sitapur and Lakhimpur districts of U.P. were conducted. Farmers earned considerably high profit from intercropping with cane over sole crop of sugarcane. Twenty FLDs on ratoon promoter in 10 ha area was also conducted.
- Twenty skill development residential training programme was organized in which 655 officers, farmers and students were trained in the area of cane production and entrepreneurship for agri-business. Eighty one trainings of one day duration and visit programme were also organized in which 2313 visitors participated.
- Three field days was organized on February 25, 2018; March 14, 2018 and March 25, 2018 at Dokti (Ballia) Lucknow and Biswan (Sitapur), respectively. Sugarcane production technology was showcased in exhibitions (11 nos.) organized at different locations of the country.

Economics, Statistics and ICT

- Sugarcane productivity and sugar recovery has improved significantly in U.P. during last three sugar seasons. However, the labour scarcity, input cost escalation, surplus sugar production and swelling cane price arrear on sugar mills due to privaling low sugar prices in the market are the key issues to be addressed.
- Cultivation of CVRC released varieties in Uttar Pradesh paved way for wider adoption of EMV's (Co 0238, CoLk 94184) with productivity gain of 15-25% and 10.88% sugar recovery.
- Sugar recovery of respondent sugar mills during crushing season 2017-18 ranged from 10.02 to 12.30%. Utilization of advance sugar processing technologies with higher efficiencies in integrated sugar-energy complexes has improved sugar recovery.
- The cost of sugar processing varied from ₹ 32,310 to ₹ 38,668/ tonne in stand alone, integrated sugar-energy complex owned by cooperative or private sector during current sugar crushing season. The ex-factory sugar price varied from ₹ 30,500-33,500 during the same period. This indicates the financial distress of sugar mills.
- The economic feasibility of sugarbeet cultivation vis-a vis that of wheat cultivation, its competing crop revealed that net returns from sugarbeet cultivation were more than double the returns being obtained from rice or wheat cultivation. Sugarbeet cultivation has increased the income levels of the growers. The weakness associated with the sugarbeet cultivation is high demand for labour for manual weeding in the wake of non-availability of an efficient weedicide.
- The monetary contribution of the sugarcane cutter planter due to labour saving was estimated to be more than ₹ 150 crores per annum. The extent of successful intercropping of sugar beet, wheat and cauliflower in Punjab State to the extent of 1.5 acres, 2.8 and 0.4 acre, respectively, per farmer. The extent of the spread of the IISR developed variety CoLk 94184 in U.P. is around 1.44 lakh ha (2017-18).
- A new website of AICRP (S) has been developed and website uploaded on NIC server. More than eighty web pages has been developed and added in the site covering information about AICRP activities.

About the Institute

The Indian Institute of Sugarcane Research (IISR), Lucknow was established on 16th February 1952 by the Indian Central Sugarcane Committee for conducting research on fundamental and applied aspects of sugarcane culture as well as to co-ordinate research work done on this crop in different states of the country. The Government of India took over the Institute from the Indian Central Sugarcane Committee on January 1, 1954, and on April 1, 1969, it was transferred to the Indian Council of Agricultural Research (ICAR), New Delhi. 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 Charbagh, 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^{0}C to 40^{0}C and minimum temperature during November to February ranges from 7^{0}C to 11.5^{0}C. The annual average rainfall is around 880 mm.

Vision

An efficient, globally competitive and vibrant sugarcane agriculture

Mission

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

Mandate

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

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

(iii) Dissemination of technologies and capacity building.

Issues and strategies

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

Issues

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

Strategies

Increasing the level of cane yield and sugar recovery

a. Introgression of untapped genes in the parental gene pool

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

c. Improving sink strength and source efficiency

d. Enhancing productivity of ratoon cane

Reducing the cost of cane cultivation

a. Nutrient use efficiency through rhizospheric engineering and INM technology

b. Water use efficiency through micro- irrigation

c. Land use efficiency though companion cropping

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

e. Mechanizing sugarcane farming

Arresting decline in factor productivity

a. Soil biological and nutritional dynamism

b. Carbon sequestering through cropping system

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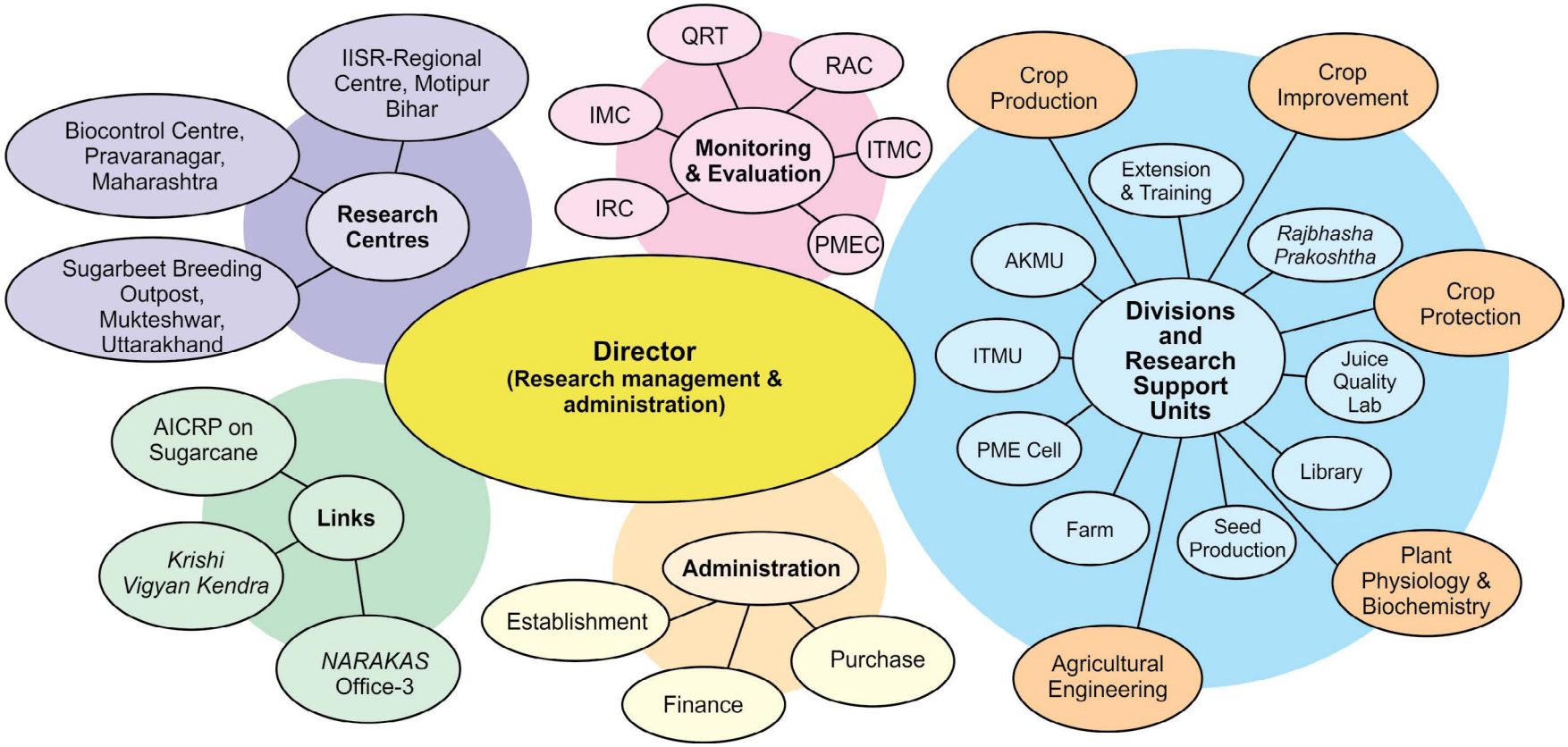

Organizational Structure

Financial statement (2017-18)

Particulars	Plan (₹ in lakh)	
	Revised Estimate	Expenditure
ICAR-Indian Institute of Sugarcane Research	5269.00	5074.14
All India Coordinated Research Project on Sugarcane	1075.49	1075.49

Staff position as on March 31, 2018

Category	Sanctioned	Filled	Vacant
Research Management Position	1	1	0
Scientific			
Principal Scientist	8	8	0
Senior Scientist	15	15	0
Scientist	50	35	15
Total	74	59	15
Technical			
Cat. I (Technician)	77	52	25
Cat. II (Technical Assistant)	54	35	19
Cat. III (Senior Technical Officer)	3	3	0
Total	134	90	44
Administrative	49	45	4
Skilled Supporting Staff	72	17	55
Total	329	211	118

CHAPTER 1

Genetic Improvement of Sugarcane for Higher Cane and Sugar Productivity

Sugarcane variety notified for commercial cultivation

CoLk 09204 (Ikshu-3), a mid-late maturing high yielding sugarcane variety was recommended for release by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties for its commercial cultivation in North West Zone of India vide its Notification No. S.O. 1379(E) dated March 27, 2018. Some key features and attributes of CoLk 09204 are given in Table 1.1 and Fig. 1.1.

Table 1.1. Salient features of newly released sugarcane variety CoLk 09204 (Ikshu-3)

Parentage	Maturity group	Cane yield (t/ha)	CCS yield (t/ha)	Sucrose % at 12 month	Pol % cane at 12 month
CoLk 8102 × CoJ 64	Mid-late	82.8	9.30	17.0	13.2

Fig. 1.1. Some key characteristics of CoLk 09204

Sugarcane varieties identified for release

Two sugarcane varieties, viz., CoLk 11203 (early) and CoLk 11206 (mid-late) were identified by the Varietal Identification Committee of the All India Coordinated Research Project on Sugarcane (AICRP-S) for their release and notification. The final proposals of these two varieties have been submitted to the Central Sub-Committee on Crop Standards, Notification and Release of Varieties for their release and notification. Some key features and attributes of CoLk 11203 and CoLk 11206 are given in Table 1.2, Fig. 1.2 and Fig. 1.3.

Table 1.2. Salient features of CoLk 11203 (Ikshu-5) and CoLk 11206 (Ikshu-4)

Variety	Paren-tage	Maturity group	Cane yield (t/ha)	CCS yield (t/ha)	Sucrose % at harvest	Pol % cane at harvest
CoLk 11203 (Ikshu-5)	CoLk 8102 × Co 1148	Early	81.97	10.52	18.41	13.44
CoLk 11206 (Ikshu-4)	CoPant 90223 × Co 62198	Mid-late	91.5	11.20	17.65	13.42

Fig. 1.2. Field view and buds of CoLk 11203 (Early)

Fig. 1.3. Field view and buds of CoLk 11206 (Mid-late)

Sugarcane clones accepted for multi-location testing

Two early maturing sugarcane clones, viz., CoLk 17201 (LG 09039) and CoLk 17202 (LG 09760), and one mid-late maturing clone, CoLk 17204 (LG 11703) were accepted during the AICRP(S) workshop held at ICAR-Sugarcane Breeding Institute, Coimbatore during 2017 for multi-location testing in North West Zone of India. Some key features and attributes of these clones are given in Table 1.3.

Table 1.3. Salient features of the sugarcane clones accepted for multilocation testing under AICRP(S)

Clone	Parentage	Maturity group	Cane yield (t/ha)	CCS yield (t/ha)	Sucrose % at harvest	Red rot rating
LG 09039 (CoLk 17201)	81 V 48 × CoH 70	Early	83.07	10.54	18.31	MR
LG 09760 (CoLk 17202)	CoS 8436 GC	Early	80.10	10.08	18.01	MR
LG 11703 (CoLk 17204)	Co 89029 GC	Mid-late	80.80	10.36	18.46	MR

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

A collection of 350 genotypes consisting of *Saccharum officinarum*, *S. barberi*, *S. sinense*, ISH clones, Ikshu ISH clones, LG selections, commercial hybrids, and somaclonal variants (25) was maintained and the required material was supplied to various on-going projects of the Institute. The collection includes 173 commercial hybrids, 51 ISH & Ikshu ISH lines, 71 LG clones and 30 species level genotypes. A 'Varietal Cafeteria' comprising of 10 early and 10 mid-late maturing varieties of Uttar Pradesh was planted in October, 2017 to provide an opportunity for farmers to select varieties of their choice.

Development of breeding stocks of sugarcane for durable resistance to red rot

Registration proposal of LG 05817 was submitted to register it as novel genetic stock of sugarcane having durable resistance (Fig. 1.4).

Fig. 1.4. Field view of LG 05817

Inclusion of genotypes in the station trial: Two promising clones, viz., LG 13825 (Co 86002 × ISH 147) and LG 13821 (CoLk 8102 × BO 91**)** having moderately resistant (MR) to three pathotypes (Cf 01, Cf 08 and Cf 09) of red rot and having sucrose content (>17.03%) were promoted to station trial 2018-19. These clones also recorded cane yield of >91 t/ha.

Evaluation and selection of resistant clones to red rot in third and fourth clonal generations: Four clones exhibited moderately resistant (MR) reaction to both pathotypes Cf 08 and Cf 09 in C_3 of 43 progenies. Seven clones, viz., LG 13806, LG 13808, LG 13820, LG 13828 and LG 13844 recorded >16.77% sucrose and MR to red rot (Cf 08 and Cf 09) were promoted to next generation for further evaluation.

Evaluation of advance clones in plant crop: A trial comprised of 10 clones was conducted in CRBD with three replications along with four checks, viz., Co 0238, CoJ 64 (early) and CoS 767, CoPant 972229 (mid-late) to evaluate their yield and quality performance. Six clones, viz., LG 12825, LG 12826, LG 13803, LG 13817, LG 13821 and LG 13825 showed MR reaction to three pathotypes (Cf 01, Cf 08 and Cf 09) of red rot. The clone LG 13821 showed the highest cane yield (93.3 t/ha) followed by LG 13803 (93.2 t/ha), LG 13817 (92.9 t/ha) and LG 13825 (91.1 t/ha) over the best check, Co 0238 (82.3 t/ha) (Table 1.4). Sucrose content at 12 month ranged from 15.09% to 19.07%. Clone LG 13827 recorded the highest cane and sugar yield but was susceptible to all the three pathotypes.

Evaluation of elite clones for durable resistance: Clone LG 05823 exhibited moderately resistant reaction to pathotypes, Cf 01, Cf 08 and Cf 09. This clone has shown resistance for last ten years.

Table 1.4. Performance of advance clones for yield and quality traits in plant crop during 2017-18

Clone	Parentage	NMC (000/ha)	CCS yield (t/ha)	Cane yield (t/ha)	Sucrose %	CCS %	Reaction to red rot		
							Cf 01	Cf 08	Cf 09
LG 13827	Co 98008 × Co 775	168.3	12.67	96.13	19.07	13.19	S	S	S
LG 13821	CoLk 8102 × BO 91	145.3	10.93	93.27	17.33	11.76	MR	MR	MR
LG 13803	Co 0238 × CoSe 92423	119.3	11.73	93.23	18.18	12.59	MR	MR	MR
LG 13807	CoLk 8102 × CoH 15	141.7	9.43	91.03	15.43	10.38	MS	MR	MR
LG 13825	Co 86002 × ISH 147	125.3	10.7	91.10	17.04	11.74	MR	MR	MR
LG 13838	BO 91 × Co 62198	92.0	5.70	47.87	17.18	11.86	MR	MR	MR
LG 13817	CoLk 8102 × BO 91	152.3	10.30	92.87	16.05	11.08	MR	MR	MR
LG 13826	Co 86002 × ISH 147	94.3	7.67	68.30	16.25	11.22	MR	MR	MS
LG 12825	ISH 100 × CoSe 92423	90.7	6.27	62.17	15.09	10.07	MR	MR	MR
LG 12826	ISH 100 × CoSe 92423	117.7	7.90	71.87	15.99	11.03	MR	MR	MR
Co 0238		96.0	10.77	82.33	18.89	13.09	MR	MR	MR
CoJ 64		90.0	5.57	45.23	17.85	12.28	S	S	S
CoS 767		123.3	10.33	89.20	16.84	11.55	MR	MS	S
CoPant 97222		98.3	9.50	78.37	17.64	12.13	MR	MS	MR
GM		118.2	9.25	78.80	17.06	11.71			
CD(0.05)		21.19	1.49	10.84	1.34	1.06			
CV %		10.61	9.58	8.20	4.65	5.31			

Development of sugarcane varieties for sub-tropics

Hybridization and seedling raising: A total of 22 bi-parental sugarcane crosses were attempted at National Hybridization Garden, ICAR-SBI, Coimbatore during the crossing season 2017. In addition, five poly-crosses were also effected. The fluff of these crosses along with the 57 GCs was received. Approximately 24,500 seedlings derived from 40 bi-parental crosses, 03 selfs, 06 poly-crosses and 38 GCs attempted during 2016 crossing season were raised and transplanted in the field for further evaluation.

Selection in seedling (C_0) population: Based on the Brix and other growth parameters, a total of 225 clones were selected from the seedling populations. These selected clones were planted as C_1 clones along with standard varieties for further evaluation.

Evaluation of advanced clonal generations: Based on juice quality, crop growth and yield parameters, 23 clones were selected in C_1 generation and promoted to C_2 generation for further evaluation. Similarly, 26 promising sugarcane clones were selected in C_2 generation and promoted to the C_3 generation. These clones were planted in replicated trials for their yield and quality evaluation and red rot testing. Based on the yield, quality and red rot ratings, four promising clones, viz., LG 10723, LG 10725, LG 11067 and LG 12040 were included in the Station Trial (2018-19).

Station Trial (2017-18): Eleven elite sugarcane genotypes developed under different projects of the Division along with four standards were evaluated (Table 1.5). LG 12042 recorded the highest cane yield (90.42 t/ha) and was significantly superior to the best standard, this was followed by LG 11517 (84.91 t/ha) and LG 012081 (81.31 t/ha). LG 12042 also recorded the highest CCS yield (12.19 t/ha) followed by the LG 11517 (12.13 t/ha) and LG 12033 (10.56 t/ha). The highest sucrose content at 10 month was recorded in Co 12033 (17.67%) followed by LG 12042 (17.53%) and LG 11084 (17.25%). These clones may be proposed as early sugarcane genotypes for the multi-location testing in North-West Zone. However, at 360 days, the highest sucrose content was recorded in LG 11517 (20.46%) which makes it a good candidate for mid-late sugarcane variety.

Development of water-logging tolerant and red rot resistant sugarcane clones for North-Central Zone

Evaluation of elite clones: A total of 27 promising sugarcane clones (CoLk 11201, CoLk 11203, CoLk 11206, CoLk 12201, CoLk 14201, CoLk 14202, CoLk 14203, CoLk 15205, CoLk 15207, LG 07454, LG 07584, LG 08422, LG 08443, LG 09110, LG 09113, LG 09487, LG 11001, LG 11067, LG 11645, LG 11663, LG 12032, LG 12033, LG 12035, LG 12038, LG 12042, LG 12061 and LG 12081) along with the Zonal Check Varieties were evaluated for yield and quality parameters.

Table 1.5. Performance of elite sugarcane genotypes under Station Trial (2017-18)

Genotype	CCS yield (t/ha)	Cane yield (t/ha)	Sucrose (%)	
			300 d	360 d
LG 10805	9.14	73.85	14.96	17.84
LG 11084	10.23	78.00	17.25	18.90
LG 11511	6.94	56.24	16.88	17.94
LG 11517	12.13	84.91	14.76	20.46
LG 11816	7.08	60.48	14.49	17.09
LG 11842	7.27	63.04	15.29	16.76
LG 12033	10.56	80.27	17.67	18.89
LG 12042	12.19	90.42	17.53	19.38
LG 12038	10.01	74.97	17.24	19.17
LG 12077	3.85	29.23	17.24	19.03
LG 12081	10.44	81.31	16.60	18.48
Standards				
CoS 767	7.34	63.50	17.22	16.85
CoPant 97222	8.82	68.47	15.64	18.54
Co 0238	9.69	69.39	17.06	20.01
CoJ 64	5.62	45.87	17.58	17.74
Mean	8.75	68.00	16.49	18.47
CV (%)	9.51	8.21	5.24	2.79
CD at 5%	1.39	9.33	1.45	0.86

Evaluation of C_1 clones: A total of 165 C_1 clones along with the standards were evaluated in augmented design. Based on the growth and quality parameters, the best promising clones were promoted to next generation for further evaluation (Table 1.6).

Hybridization and seedling raising: Bi-parental crosses, GCs were attempted at NHG, ICAR-SBI, Coimbatore during November 2017. Seedlings from the crosses of 2016 crossing year were raised in the glasshouse were transplanted in the field.

Evaluation of sugarcane clones for North-West Zone [AICRP(S)]

AICRP(s) Trials: Two sugarcane clones, viz., CoLk 14206 (early) and CoLk 14208 (mid-late) were promoted to Advanced Varietal Trial in AICRP(S) of North Central Zone for multilocation testing. In addition, 10 sugarcane clones (CoLk 15466, CoLk 15467, CoLk 15468, CoLk 15469, CoLk 16466, CoLk 16467, CoLk 16468, CoLk 16469, CoLk 16470 and CoLk 16471) were under seed multiplication to conduct the multi-location trials.

Initial Varietal Trial (early): A trial comprising of seven test sugarcane genotypes (Co 14034, CoLk 14201, CoLk 14202, CoPant 14222, CoPb 14181, CoPb 14182 and CoPb 14211) and three standards (CoJ 64, Co 0238 and Co 05009) was conducted and observations were recorded on various yield and quality parameters. CoLk 14201 recorded the highest cane yield (78.56 t/ha) closely followed by Co 14034 (78.13 t/ha). Similarly, the genotype CoLk 14201 had also shown the highest CCS yield (10.09 t/ha) followed by Co 14034 (9.98 t/ha). The highest sucrose content at harvest was recorded in Co 14034 (18.56%) followed by CoLk 14201 (18.40%) and CoPb 14181 (18.06%). Among the standards, Co 0238 was found the best standard for both yield and quality parameters and recorded cane yield (74.67 t/ha) and CCS yield (9.77 t/ha).

Table 1.6. Details of C_1 clones evaluated for yield and quality parameters

Cross	Number of clones
CoS 8436 × Co 0233	3 (A1-A3)
Co 1158 × Co 62198	9 (B1-B9)
CoLk 7901 × ISH 176	3 (C1-C3)
CoSe 95422 × CoS 8436	12 (D1-D1)
LG 05460 × CoSe 92423	24 (E1-E24)
CoP 06436 × BO 130	5 (F1- F5)
CoS 8436 × Co 1148	8 (G1-G8)
BO 91 × CoH 15	12 (H1-H12)
UP 9530 × CoP 9301	5 (I1-I5)
CoJ 80 × Co 86011	2 (J1-J2)
BO 97 × BO 32	11 (K1-K11)
CoSe 95422 × Co 62198	29 (M1-M29)
BO 91 × Co 62198	9 (N1-N9)
LG 06810 × CoSe 92423	1 (O1)
CoLk 94184 × BO 91	9 (P1-P9)
CoLk 8102 × Co 62198	3 (R1-R3)
CoSe 96436 × Co 0233	6 (U1-U6)
CoP 06436 × CoPant 97222	14 (W1-W14)
Total	**165**

Advanced Varietal Trial I-Plant (Early): Three sugarcane genotypes, viz., Co 13034, CoPb 13181, CoS 13231 along with three standards (CoJ 64, Co 0238 and Co 05009) were evaluated. None of the test genotypes was found superior to the best standard Co 0238. Among the test genotypes, CoPb 13181 recorded the highest cane yield (54.02 t/ha) and CCS yield (6.13 t/ha). CoPant 13231 showed the highest sucrose content at harvest (17.42%) followed by Co 13034 (17.18%). Among the standards, Co 0238 was the best check with yield (73.35 t/ha) and CCS (8.45 t/ha).

Advanced Varietal Trial II-Plant (Early): Four sugarcane clones, viz., Co 12026, Co 12027, CoLk 12203 and CoPant 12221 along with two standards (CoJ 64 and Co 0238) were evaluated. CoLk 12203 recorded the highest cane yield (77.10 t/ha) followed by Co 12027 (52.83 t/ha) and CoPant 12221 (47.44 t/ha). Similarly,

CoLk 12203 also showed the highest CCS yield (9.34 t/ha) followed by Co 12027 (6.63 t/ha) and CoPant 12221 (5.88 t/ha). Among the test genotypes, Co 12026 recorded the highest (18.24%) sucrose content at harvest followed by Co 12027 (18.15%) and CoPant 12221 (17.94%). Co 0238 recorded cane yield (78.33 t/ha) and CCS yield (10.05 t/ha).

Advanced Varietal Trial-Ratoon (Early): Four sugarcane clones, viz., Co 12026, Co 12027, CoLk 12203 and CoPant 12221 along with two standards (CoJ 64 and Co 0238) were evaluated for their ratooning ability. CoLk 12203 had shown the highest cane yield (60.05 t/ha) and CCS yield (6.29 t/ha). Among the standards, Co 0238 was better then CoJ 64.

Seed multiplication (Early): The seed of ten sugarcane genotypes, viz., Co 15023, Co 15024, Co 15027, CoLk 15201, CoLk 15202, CoLk 15203, CoLk 15204, CoLk 15205, CoPb 15211 and CoPb 15212 was multiplied for next year IVT trial.

Initial Varietal Trial (Mid-late): Thirteen sugarcane clones, viz., Co 14035, CoH 14261, CoH 14262, CoLk 14203, CoLk 14204, CoLk 14205, CoPb 14183, CoPb 14184, CoPb 14185, CoPb 14212, CoS 14231, CoS 14232 and CoS 14233 along with four standards (CoS 767, CoS 8436, CoPant 97222 and Co 05011) were evaluated for yield and quality parameters. The genotype CoS 14231 recorded the highest cane yield (106.66 t/ha) followed by CoPb 14183 (103.87 t/ha) and CoS 14232 (98.77 t/ha). CoS 13231 showed the highest CCS yield (13.98 t/ha) followed by CoPb 14183 (12.59 t/ha) and CoLk 14203 (12.05 t/ha). Among the test genotypes, CoH 14261 recorded the highest (18.86%) sucrose content at harvest followed by CoS 14231 (18.72%) and CoLk 14203 (18.64%). Among the standard varieties, CoPant 97222 recorded the highest CCS yield (11.58 t/ha) followed by Co 05011 and CoS 767.

Advanced Varietal Trial I-Plant (Mid-late): Five sugarcane genotypes, viz., Co 13035, CoH 13263, CoPant 13224, CoPb 13182 and CoLk 13204 along with four standards (CoS 767, CoS 8436, CoPant 97222 and Co 05011) were evaluated. CoLk 13204 recorded the highest (92.36 t/ha) cane yield, whereas, CoH 13263 exhibited the highest (19.63%) sucrose content at harvest followed by CoPant 13224 (18.71%) and Co 13182 (18.30%). Among the standard varieties, Co 05011 was found the best for both cane yield (78.09 t/ha) and CCS yield (10.23 t/ha).

Advanced Varietal Trial II Plant (Mid-late): Six genotypes viz., Co 12029, CoH 12263, CoLk 12205, CoPant 12226, CoPb 12211 and CoS 12232 along with three standards (CoS 767, CoS 8436 and CoPant 97222) were evaluated. CoLk 12205 recorded the highest cane yield (88.32 t/ha) followed by CoH 12263 (80.45 t/ha) and Co 12029 (77.00 t/ha). CoLk 12205 recorded the highest CCS yield (11.03 t/ha) followed by CoPant 12226 (10.39 t/ha) and CoS 12029 (10.19 t/ha). CoPant 12226 recorded the highest sucrose content at harvest (19.55%) followed by Co 12029 (18.98%). Among the standards, CoPant 97222 was the best check for cane yield (78.83 t/ha) and CCS yield (10.39 t/ha).

Advanced Varietal Trial-Ratoon (Mid-late): Six genotypes, viz., Co 12029, CoH 12263, CoLk 12205, CoPant 12226, CoPb 12211 and CoS 12232 along with three standards (CoS 767, CoS 8436, CoPant 97222) were also evaluated for their ratooning ability. CoLk 12205 recorded the highest cane yield (73.14 t/ha), CoPant 12226 recorded highest CCS yield (8.42 t/ha). Among the standard varieties, CoS 767 and CoPant 97222 were at par for cane as well as CCS yield.

Seed multiplication (Mid-late): The seed of 11 genotypes, viz., Co 15026, CoLk 15206, CoLk 15207, CoLk 15208, CoLk 15209, CoPb 15213, CoPb 15214, CoS 15231, CoS 15232, CoS 15233 and CoS 15234 was multiplied for next year IVT trial.

Elucidation of the role of species chromosomal complement in sugarcane genotypes adapted to sub-tropical conditions

Chromosome number variability studies in a sugarcane genotype CoLk 8102 and clonal populations of CoLk 8102 (GC) revealed that the variation in somatic chromosome number gradually narrowed down in consecutive clonal generations from C_1 to C_3. Fluorescence *in situ* hybridization using 5S ribosomal DNA probes on random samples from these clonal generations indicated a decline in range of variation of signals from C_1 to C_3 generations. The signals were faint but the reduced variation in their number from C_1 to C_3 indicated a trend towards stabilization of chromosome number in progeny plants.

Mapping of loci linked to sugar content in sugarcane

Segregating population from bi-parental crosses and selfs were maintained in the field. High sugar clones in different generations were evaluated. Genotyping for a selfed population was carried out with 20 primer pairs. Genotypes in seedling generation as well as different clonal generations were evaluated and promising selections were further advanced (Table 1.7). A total of 194 high sugar genotypes from C_1 generation were selected based on HR Brix and were advanced to C_2. Out of the 98 genotypes in C_2, 57 genotypes having >17% mean sucrose content in juice

Table 1.7. Sugarcane genotypes evaluated and selected in various generations

Seedling/ clonal generation of selection	Number of matings	Number of genotypes evaluated	Number of genotypes selected
C_0	16	2500	298
C_1	9	292	194
C_2	15	98	57
C_3	-	40	25

during January were selected and planted for further evaluation.

A trial comprising of 40 promising high sugar genotypes in advanced generation gave 14 genotypes with 17-18% mean sucrose content in juice in January (Table 1.8). Eleven more promising genotypes from a previous trial were also planted along with these for further evaluation and selection. Out of the 34 high sugar genotypes tested against red rot during 2017-18, 20 genotypes gave MR reaction for the pathotypes Cf 08 and Cf 09. Three promising clones (LG 11406, LG 13430 and LG 12429) were included in the Divisional station trial. Two high sugar genetic stocks, viz., LG 09487 and LG 09475 with 17-18% mean sucrose content were sent to NHG, ICAR-SBI, Coimbatore.

Seedlings from 16 matings were evaluated and 298 selections having more than 20% mean HR brix during early November and January were advanced to C_1 generation. The bi-parental cross of LG 07501 × LG 07482 gave the maximum family mean of 21.78 for HR Brix (Table 1.9). The crosses/matings involving the high sugar genotypes LG 07482 and LG 07501 gave family mean values of >20% with respect to HR Brix.

Table 1.8. Performance of a few promising genotypes

Genotype	Corrected Brix (%)	Sucrose (%)	Purity (%)	CCS (%)
LG 12461	19.18	17.15	89.43	11.93
LG 11440	19.43	17.46	89.88	12.17
LG 14550	19.30	17.19	89.08	11.93
LG 12478	19.77	17.81	90.11	12.43
LG 11533	18.92	17.24	91.16	12.09
LG 13439	20.11	18.29	90.94	12.82
LG 14454	19.37	17.43	90.00	12.16
LG 13430	20.03	18.07	90.22	12.62
LG 11543	20.16	17.56	87.12	12.06
LG 12426	20.30	17.15	87.44	11.60
LG 11528	19.89	17.24	86.68	11.81
LG 11459	20.14	17.54	87.10	12.05
LG 11406	19.42	17.30	89.08	12.01
LG 12429	21.95	18.93	86.22	12.94
Mean#	18.69	16.50	88.34	11.40
CV#	6.94	7.29	2.36	7.74

#: Parameters for the 40 genotypes tested in the trial.

Table 1.9. Performance of seedling generation (C_0) with respect to HR brix values

Mating	HR Brix Family Mean (%)	HR Brix Range (%)	Number of seedlings	
			Evaluated	Selected
LG 08422 × LG 07482	20.69	14-25	160	88
LG 07501 × LG 05493	20.83	14.2-26	50	15
LG 07501 × LG 07482	21.78	16.8-27.4	50	25
LG 07560 × LG 05493	-	17.2-22	2	1
LG 99001 GC	18.87	10.2-23.2	63	22
LG 08432 GC	19.90	13.4-24.4	80	41
LG 05460 GC	18.08	9.2-27	190	30
CoLk 97009 GC	14.75	10.4-20.6	40	9
LG 02100 GC	19.10	11.4-23.4	40	4
LG 01014 GC	18.64	15-21.2	280	41
LG 07501 GC	20.54	16-25	80	22
LG 99122 GC	18.83	16-23	20	3
LG 07560 GC	-	20.8-21.6	2	1
LG 07480 GC	-	20-21	1	1
LG 95123 GC	12.42	10-17.4	296	-
LG 07482 Self	-	18.2-22.2	2	2

Identification and expression analysis of resistance gene analogues against red rot of sugarcane

Validation of putative RGAs from the conserved motifs of the resistance genes was continued using homology-based PCR to target the nucleotide binding site (NBS) conserved regions from sugarcane. Total RNA isolated from stalk tissue of red rot inoculated and control samples of CoJ 64 (red rot susceptible) and BO 91 (red rot resistant) was used for cDNA synthesis and PCR using 28 putative RGA markers. The expression of RGA markers was observed in all the primers and it was more prominent in BO 91. Seven more putative RGAs identified this year were also validated in the same way. Further, amplification of genomic DNA from 55 sugarcane genotypes of sub-tropical India using selected RGA primers showed high degree of polymorphism, indicating the use of RGAP (resistance gene analogue polymorphism) as a tool for diversity analysis in sugarcane.

Profiling and prediction of small RNA transcriptomes in sugarcane inoculated with red rot pathogen

Two varieties, viz., BO 91 (red rot resistant) and CoJ 64 (red rot susceptible) were inoculated with *C. falcatum* (pathotype Cf 08). Total RNA was isolated at different time intervals from stalks and leaves after inoculation along with control, and small RNA enrichment was also done. Selected small RNA samples, after cDNA synthesis and adapter ligation was used for library preparation. The quality of small RNA libraries was checked with bioanalyzer. The size ranged from 140 bp to 162 bp and the peak concentration ranged from 7.7 to 14.86 ng/µl. QC passed libraries are being sequenced for further analysis.

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

Rapid *in vitro* cultures of new sugarcane varieties CoLk 09204, CoLk 11203, CoLk 11206 were established for multiplication along with Co 06034 and Co 0238 through enhanced axillary shoot proliferation using apical shoot explants. Shoot initiation was achieved on Murashige and Skoog's medium supplemented with 4.44 µM benzyladenine (BA) and 4.6 µM kinetin (Kin) + 3% sucrose. The maximum shoot proliferation per explant with 100% shoot regeneration frequency was obtained on MS medium supplemented with 2.22 µM BA + 2.3 µM Kin + 26.8 µM NAA + 3% sucrose. Vigorous rooting was obtained on MS medium containing 26.8 µM NAA and 5% sucrose. In this way, more than 10,000 plantlets of varieties CoLk 09204, CoLk 11203, CoLk 11206, Co 06034 and Co 0238 were multiplied.

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

A protocol for *in vitro* conservation of sugarcane genotype Khakai (*Saccharum sinense*) using slow-growth culture technique is being developed. The shoot-tip explants were established and multiplied on MS medium with 2.22 µM BA, 0.5 µM Kinetin, 0.5µM GA_3. The evaluation of high osmoticum (0-10% sucrose in the medium), two temperature regime (8^0C and 25^0C) was completed. The best concentration (5% sucrose in MS medium with 2.22 µM BA, 0.5 µM Kinetin, 0.5µM GA_3) was tested this year with a chemical growth retardant flurprimidol (1.0-10.0 µM). The cultures stored for 180 to 360 days without any sub-culturing. The green parts of the stored shoots were re-cultured for regeneration/multiplication ability on MS medium with 2.22 µM BA, 0.5 µM Kinetin, 0.5µM GA_3 and 3% sucrose. Successful shoot multiplication was recorded from such stored slow-growing shoots. Genetic fidelity assay using ISSR markers revealed no genetic variation in the recovered cultures.

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

An Accredited Test Laboratory (ATL) for genetic fidelity and virus indexing of tissue culture raised plants is under operation at ICAR-IISR, Lucknow with the financial support from Department of Biotechnology (DBT), New Delhi under National Certification System of Tissue Culture-raised Plants (NCS-TCP). During 2017-18, more than 2650 samples comprising of ~650 samples of sugarcane and ~2000 samples of banana from DBT recognized tissue culture production facilities were tested for virus indexing and genetic fidelity for batch certification. Of the 2,650 samples, a total of 1,450 samples (500 of sugarcane and 905 samples of banana) were tested for genetic fidelity, which equals to quality certification of 14.5 lakh tissue culture plantlets, for which test reports, certificate of quality as well as quality labels were issued. This testing also included virus indexing of 1,200 mother cultures, 100 sample of sugarcane for Sugarcane mosaic virus (SCMV), Sugarcane yellow leaf virus (SCYLV), Sugarcane bacilliform virus (SCBV), and phytoplasma and 1100 samples of banana for Banana bract mosaic virus (BBrMv), Cucumber mosaic virus (CMV), Banana bunchy top virus (BBTV), and Banana streak virus (BSV)].

RNA seq for SNP mining and linkage mapping in sugarcane (DBT-BioCARe Project)

The application of emerging genomic tools, and next generation sequencing (NGS) technologies have immense potential in understanding the genetics and breeding of sugarcane. An F_1 mapping population was developed using two sugarcane lines MS 68/47 and CoV 92102 that have contrasting sucrose content, and a total of 262 F_1 plants were maintained. Phenotyping of two parents and 262 F_1s for TSS, NMCs, leaf width, cane diameter and cane length was done for two consecutive years. The highest sucrose content was recorded in genotype MSC 170 (17.36%) followed by MSC 162 (16.11%), whereas, it was the lowest in MSC 331 (6.79%) followed by MSC 217 (7.4%). In terms of cane diameter, the genotypes MSC 202 and MSC 36 were superior among the mapping populations. RNA seq data was generated from four samples, viz., MS 68/47 (parent 1; low sucrose), CoV 92102 (parent 2; high sucrose), high sucrose F_1 bulk and low sucrose F_1 bulk, while the genotyping by sequencing (GBS) of ~148 F_1 progeny is underway. The *de novo* sequence assembly and functional annotation is completed. Differential gene expression, indels and alternate splicing events were identified between the two parental lines and further confirmed in the two bulks for the unigenes predominantly involved in ion trans-membrane transport, glucose metabolic process and small molecule biosynthetic process (Fig. 1.5).

Ten clones showing high sucrose content, cane thickness and number of millable canes have been identified from this population and these superior clones will be evaluated for stability of performance in the next growing seasons. These clones (MSC 170, MSC 134, MSC 162, MSC 236, MSC 183, MSC 201, MSC 31, MSC 165, MSC 186 and MSC 136) have also been planted at National Hybridization Garden, ICAR-SBI, Coimbatore in February 2018 for further evaluation and selfing to produce F_2 mapping population.

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

Maintenance of reference collection of sugarcane varieties: Reference collection was planted in spring and autumn to observe the difference in DUS characteristics arising due to planting in different seasons. During the year 2017-18, a total of 144 reference varieties of sugarcane were planted in DUS field in autumn and 154 reference varieties during spring. 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. Characters are being recorded on new inclusions in reference collection as per the DUS testing guidelines.

DUS testing trial: One farmer's variety Kaptan Basti was planted during March 2017 along with four most similar varieties (CoS 96258, Co 6425, CoPant 96219 and BO 130) from reference collection following the DUS testing guidelines. Recommended package of practices were followed. Observations were recorded as per guidelines.

New candidate varieties: Two sugarcane varieties, viz., CoN 05071 and CoN 07072 were received from Navsari Agriculture University, Gujarat, however, these clones and centre falls under tropical region. Concerned Centre was suggested to supply seed of these varieties to ICAR-SBI, Coimbatore for DUS test.

Farmers' varieties testing

Fusen: During the year, another clone Fusen was received and poly-bag seedlings were raised. Out of 128 single buds received, only 12 buds sprouted. The poly-bag seedlings were transplanted in the field. Most of the plants dried during the grand growth phase. This year, the clone was again multiplied and planted in the field.

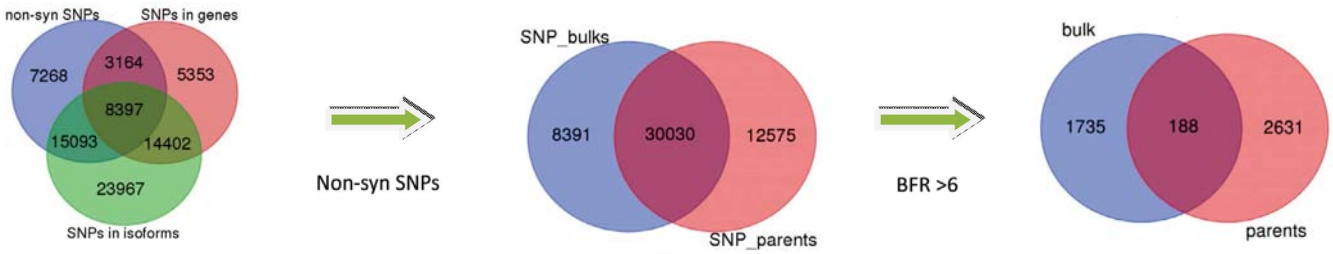

Fig. 1.5. Significant SNPs (unique and common) linked to early sucrose accumulation in sugarcane using bulk seggregant analysis

Kudrat ka karisma: This clone was received during March 2017 from ICAR-SBI-RC, Karnal. Polybag-raised seedlings were planted in the field for multiplication and evaluation. No reference variety is available for trial of this clone as every node having multiple number of buds but in entire reference collection, no clone was found with this characteristic. It indicates that this clone is suitable for DUS registration.

Other farmers' variety: The centre has received clones, viz., A1, A2, Jeet Katari, Sugam Katari, GNS-4, GNS-6 for evaluation under farmers' category. These materials were planted in the field for multiplication.

Seed production in agricultural crops (ICAR Seed Project)

During year 2017-18, approximately 9,500 q of seed cane was produced (Table 1.10). In addition, 12.0 ha area was planted with newly released varieties for seed cane production during 2018-19. New varieties included in the seed production from the current year are CoLk 11206, CoLk 11203 and CoLk 14201.

Under Seed Cane Awareness, seed of newly released varieties CoLk 09204, CoLk 9709 and CoPK 05191 were distributed to farmers and several sugar mills for making the sugarcane growers aware about the role of new varieties and the quality seed cane in enhancing the yield and production. The awareness campaign under '*Mera Gaon, Mera Gaurav*' Scheme also prompted many farmers to visit the Institute for purchase of seed cane. Field Days to popularize newly identified varieties, viz., CoLk 11203 and CoLk 11206 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 1.10. Sugarcane Seed Production at ICAR-IISR, Lucknow during 2017-18

Variety	Maturity group	Quantity produced (q)
CoPK 05191	Early	2200
CoLk 94184	Early	900
CoLk 9709	Early	1200
Co 0238	Early	1000
CoLk 09202	Early	600
Co 0118	Early	300
Co 05011	Mid-late	700
CoH 0128	Mid-late	400
CoPant 05224	Mid-late	400
CoLk 09204	Mid-late	1200
CoLk 06034	Mid-late	600
Total		**9500**

Bihar breeder seed production programme

Under this project, IISR RC, Motipur is producing breeder seed of recommended varieties with support of Sugarcane Industries Department, Government of Bihar. During 2017-18, breeder seed production was carried out in IISR RC, Motipur; Harinagar Sugar Mills Ltd. Harinagar; Vishnu Sugar Mill, Gopalganj; Jayshree Sugar Mill, Majholia; Tirupathi Sugars Ltd., Bagaha and New Swadeshi Sugar Mill, Narkatiaganj. This year, nearly 27,000 q breeder seed of CoLk 94184, Co 0238, Co 0118, Co 0232 and CoP 112 was produced.

CHAPTER 2

Natural Resource Management

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

In the continuing field experiment on soil organic carbon (SOC), the performance of second ratoon crop as influenced under various treatments was assessed during the year 2017-18. Data depicted in Table 2.1 evinced that initial soil organic carbon content neither influenced the initial shoot count (60 DAI) nor was influenced by the different nutrient management practices. However, SOC level up to 0.56-0.65% caused significant increase in the number of tillers at 120 and 180 DAI over that with SOC level 0.45-0.55%. The number of millable canes (NMC) increased appreciably up to 0.66-0.75% SOC as compared to that with SOC 0.45-0.55%. The highest NMC (112.44 thousand/ha) was recorded in the treatment with 0.66-0.75% SOC. Ratoon yield significantly increased with increasing SOC content and the highest cane yield (87.54 t/ha) was attained with > 0.76%, however, yield was at par with the yield levels recorded under 0.56-0.65 and 0.66-0.75% SOC. Higher SOC (0.56-0.65% or above) did not influence the cane thickness (NS).

Different nutrient management practices adopted in ratoon crop did not influence the crop performance as statistically similar growth and yield parameters were recorded. Influence of SOC levels and nutrient management on juice quality attributes was also not conspicuous. Effect of interaction between SOC levels and nutrient management practices was not found significant in the second ratoon crop.

Soil quality assessment under different sugarcane growing system

Alluvial soils of sub-tropical India are major sugarcane producing areas of the country. Apart from the climatic and edaphic factors, the mismanagement of irrigation water and imbalance use of mineral fertilizers

Table 2.1. Effect of initial soil organic carbon content (SOC) and nutrient management on growth and yield of sugarcane ratoon

Treatment	Shoot count 60 DAI ('000/ha)	Tiller no. ('000/ha)		NMC (000/ha)	Cane length (m)	Cane girth (cm)	Cane yield (t/ha)
		120 DAI	180 DAI				
Initial SOC level							
0.45-0.55	152.15	138.00	120.72	75.39	2.36	1.98	63.94
0.56-0.65	151.34	206.24	148.76	103.32	2.39	1.98	83.88
0.66-0.75	132.52	210.76	156.55	112.44	2.49	1.95	82.01
≥ 0.76	138.03	212.43	154.78	110.40	2.50	1.97	87.54
SEd ±	18.21	12.32	9.03	3.69	0.08	-	3.29
CD (*P*=0.05)	NS	25.96	18.18	7.83	NS	NS	6.88
Nutrient management							
RDF (150:60:60 kg NPK/ha)	127.35	180.19	144.88	97.92	2.39	1.95	77.18
RDF + FYM (10 t/ha)	149.49	203.25	150.03	101.34	2.53	1.95	81.17
RDF + $ZnSO_4$ 25 kg + S 20 kg/ha	153.13	192.43	140.72	101.90	2.38	2.00	79.68
SEd ±	--	10.78	--	--	0.14	--	2.85
C D (*P*= 0.05)	NS	22.48	NS	NS	NS	NS	6.12

are the common concern which are causing apparent deterioration of soil quality and cane productivity. A field study was conducted to assess the effectiveness of different sugarcane growing conditions and fertilizer management to determine soil quality index and their relation with cane productivity. Three sugarcane growing conditions viz., sub optimum (SO), optimum (OP) and water-logged (WL) and two fertilizer use pattern viz., farmers' practice (FP) and recommended dose of mineral fertilizers (RDF) were assessed.

The results revealed that growing of sugarcane in WL conditions had no apparent effect on soil pH and EC but imbalance fertilization (FP) slightly increased soil pH. The soil organic carbon (SOC), available N, available P, microbial biomass carbon, microbial biomass nitrogen, microbial counts (TCB, TCA and AZO) and enzymatic activities (DHA, ACP and ALP) were the highest in RDF under OP conditions. However, available K, sulphur, total cultivable fungi (TCF) and FDHA were the highest in FP under WL conditions. The micronutrients viz., Zn, Cu, Fe and Mn concentration were higher in WL conditions. There was a high variability of cane yields among the 198 sugarcane fields in FP and RDF under SOP, OP and OWL conditions with mean values of 40.8, 53.9, 60.0, 89.3, 52.6 and 80.6 t/ha and coefficient variations 12.8, 12.2, 13.2, 6.27, 23.5 and 7.42%, respectively. Table 2.2 clearly indicates that application of imbalance mineral fertilizers (FP) significantly affected cane yield over balanced application of mineral fertilizers (RDF) under all the sugarcane growing systems. However, among the sugarcane growing systems, SOP condition had worst effect on cane yield followed by OWL and OP condition. Significantly higher average cane yield (89.3 t/ha) was recorded in RDF under OP conditions followed by RDF (80.6 t/ha) under OWL which augmented about 10.8% more over later one (Table 2.2).

The imbalance mineral fertilization (FP) practices under OWL conditions had worst effect on cane yield followed by OP and SOP and decreased cane yield about 34.7, 32.8 and 24.3%, respectively over RDF. The MBN, ALP, *Azo*, $N_{av.}$, $S_{av.}$, and SOC were identified as soil quality indicators. $N_{av.}$ (14.5%) that gave the highest average contribution towards the SQI development followed by *Azotobacter* counts (12.4%) > MBC (12.2%) > ALP (10.9%) > $P_{av.}$ (10.2%) > SOC (9.40%) > $S_{av.}$(8.97%) (Fig. 2.1). This clearly reflects that in the present scenario, N, P, SOC and S are the driving force for sustaining cane productivity in different sugarcane growing conditions and nutrient management practices.

Carbon sequestration assessment in sugarcane based cropping system

The experiment was carried out to improve the total soil organic carbon (SOC) build-up and sustain crop yields under rice-wheat and sugarcane-ratoon-wheat systems (Fig. 2.2). Soil analysis of experimental

Table 2.2. Effect of different sugarcane growing systems and fertilizer management practices on soil quality index and cane yield

Sugarcane growing system	Fertilizers practices		Soil quality index	Cane yield (t/ha)
SOP	FP	Range	0.57−0.79	32.9-50.0
		Mean	0.67 ± 0.05d	40.8 ±5.2e
		$CV_{\%}$	7.80	12.8
	RDF	Range	0.57−0.91	43.9-65.4
		Mean	0.73 ± 0.09c	53.9 ±6.6d
		$CV_{\%}$	11.8	12.2
OP	FP	Range	0.61−0.94	43.7-77.7
		Mean	0.76 ± 0.08c	60.0 ±7.9c
		$CV_{\%}$	11.0	13.2
	RDF	Range	0.76−1.03	80.0-102.3
		Mean	0.91 ± 0.07a	89.3 ±5.6a
		$CV_{\%}$	7.26	6.27
OWL	FP	Range	0.55−0.90	30.0-75.0
		Mean	0.75 ± 0.1c	52.6±12.4d
		$CV_{\%}$	12.9	23.5
	RDF	Range	0.68−0.99	70.0-92.5
		Mean	0.83 ± 0.08b	80.60±6.0b
		$CV_{\%}$	9.28	7.42

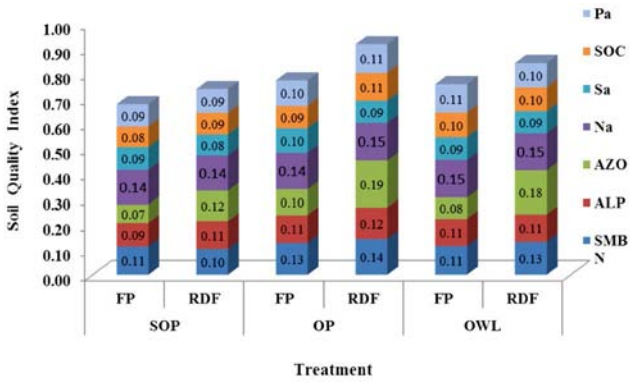

Fig. 2.1. Effect of different sugarcane growing systems on soil quality index

field revealed that rice-wheat cropping system had low mean organic carbon (0.36%) as compared to sugarcane based cropping system (0.43%) in 0-30 cm depth of soil. SOC subsequently decreased in 30-60 cm depth. Mean available nutrient status in soil decreased as compared to initial status of soil. During second year of experimentation, rice-wheat cropping system recorded grain yield of rice and wheat in tune of 41.6 and 35.9 q/ha, respectively (Table 2.3). Ratoon crop yielded 109.8 t/ha in sugarcane based cropping system. Higher wheat yield (46.9 q/ha) was recorded in sugarcane based cropping system just after harvest of ratoon crop as compared to 35.9 q/ha in rice-wheat system. Residue retention with *Trichoderma* improved the wheat yield by 11.2% in rice-wheat based cropping system. However, trash mulching with *Trichoderma* in ratoon crop improved the cane yield by 9.5% as compared to mulching without *Trichoderma.*

Fig. 2.2. A view of field experimentation on carbon sequestration under sugarcane based cropping systems

Evaluation of sulphur and zinc containing complex fertilizers for enhancing yield through balanced nutrition of different crops

Field experiment was conducted to evaluate the sulphur and zinc containing complex fertilizers in sugarcane-potato based intercropping system. Intercropping of potato with sugarcane showed higher status of SOC (0.69%), available N (218.15 kg/ha),

Table 2.3. Yield of rice, wheat and sugarcane crop under various cropping systems

Cropping System	2016-17		2017-18	
	Rice (q/ha)	Wheat (q/ha)	Rice (q/ha)	Wheat (q/ha)
T_1: Rice – Wheat – Rice – Wheat (Residue retention without *Trichoderma*)	41.7	44.2	42.4	34.1
T_2: Rice – Wheat – Rice – Wheat (Residue retention with *Trichoderma*)	42.8	47.3	40.8	37.8
Mean	**42.3**	**45.8**	**41.6**	**35.9**
Sugarcane-Wheat				
		Plant crop yield (t/ha)	**Ratoon crop yield (t/ha)**	**Wheat yield (q/ha)**
T_3: Sugarcane – Ratoon (Trash mulching without *Trichoderma*) – Wheat		110	110	48.7
T_4: Sugarcane – Ratoon (Trash removal without *Trichoderma*) – Wheat		116	107.5	45.8
T_5: Sugarcane – Ratoon (Trash mulching with *Trichoderma*) – Wheat		107	120.5	49.8
T_6 : Sugarcane – Ratoon – Wheat (Trash incorporation through rotavator and *Trichoderma* incorporation before sowing of wheat)		119	103.3	46.7
T_7: Sugarcane – Ratoon – Wheat (Zero tilled) without *Trichoderma*		107	109.1	43.8
T_8: Sugarcane – Ratoon – Wheat (Zero tilled) with *Trichoderma*		113	108.7	46.5
Mean		**112**	**109.8**	**46.9**

available K_2O (281.76 kg/ha) available S (45.74 mg/kg) and available Zn (2.12 mg/kg) content as compared to potato-sugarcane sequential system. Total uptake of nitrogen, phosphorus, potash and sulphur in stem contributed about 85% at maturity and corresponding value for at GGS was 59, 62 and 57%, respectively. Significant highest uptake of N, P, K, and S in sugarcane was registered with application of recommended NPK+S and Zn equivalent to NPSZn. Mean total nitrogen uptake at harvest increased about 113% compared to GGS. The corresponding value for phosphorus, potash and sulphur was about 135, 115, and 158%, respectively. Mean sulphur uptake ranged from 33.8 - 59.8 kg/ha in stem and 3.4-6.7 kg/ha in leaves of sugarcane. Results also revealed that cropping system improved all yield attributes with non significant differences. Nutrient management schedule significantly affected the cane yield, quality and yield parameters (Table 2.4). The highest potato tuber (345.2 q/ha) and sugarcane yield (109.8 t/ha) were recorded with application of recommended NPK + Zinc and Sulphur equivalent to NPSZn which was closely followed by application of recommended P through NPSZn (Grade III) material. The higher tuber and cane yield was realized because of higher NMC, single cane weight, mean tuber weight, LAI and photosynthetic rate. Nutrient uptake pattern followed the similar trend as observed in yield of potato and sugarcane during the both the years of experimentation. The highest nitrogen use efficiency was determined with recommended NPK + FYM and the value ranged from 20-49%. Potato + Sugarcane intercropping system observed higher cane equivalent yield (129.4 t/ha), benefit cost ratio (2.65) and net income (₹ 2.54 lacs/ha) as compared to potato-sugarcane sequential system. Among all nutrient management schedules, recommended NPK + S and Zn equivalent to NPSZn and NPSZn exhibited superiority and recorded the highest benefit cost ratio as compared to other nutrient management schedules. Evaluating material as recommended P through NPSZn (Grade III) was found comparatively better compared to NPS-2 (Grade II) and NPS-1 (Grade-I), as these improved the net profit by ₹ 16,000/-and ₹ 27,000/- respectively.

Table 2.4. Yield and economic analysis as influenced by cropping system and nutrient management schedule

Treatment	NMC (000/ha)	Cane yield (t/ha)	CCS (t/ha)	NUE (%) N	Yield (mean over two years)		Net profit (₹ lacs)	Benefit: cost ratio	Cane equivalent yield (t/ha)
					Potato (q/ha)	Sugarcane (t/ha)			
A- Cropping system									
C_1	118.26	98.73	10.98	23.7	311.93	95.96	2.37	2.49	125.73
C_2	123.48	104.27	11.82	29.2	300.62	100.88	2.54	2.65	129.54
CD (P= 0.05)	**NS**	**NS**	**NS**						
B- Nutrent management schedule									
T_1	105.44	79.05	8.39	00.00	206.2	70.34	1.56	2.22	89.99
T_2	116.78	95.80	10.41	19.21	292.4	94.78	2.32	2.51	122.65
T_3	119.78	99.89	11.10	20.45	296.1	98.80	2.36	2.44	127.01
T_4	125.43	108.35	12.38	24.97	322.6	105.00	2.61	2.57	135.73
T_5	127.89	112.03	13.03	42.49	324.8	106.41	2.60	2.50	137.33
T_6	117.00	97.00	10.70	28.25	314.1	96.46	2.46	2.61	126.37
T_7	119.89	101.29	11.26	33.49	324.0	100.07	2.57	2.66	130.97
T_8	125.00	106.20	12.06	33.05	331.1	104.37	2.73	2.76	135.96
T_9	130.67	113.91	13.24	36.19	345.2	109.59	2.92	2.86	142.62
CD (P= 0.05)	13.37	7.78	0.87						

*C_1- Potato- Sugarcane ; C_2- Potato+ Sugarcane **T_1- Absolute control (No N,P,K) T_2- Recommended dose of N,P,K T_3- Recommended dose of N,P,K,S T_4- Recommended dose of N,P,K,S,Zn T_5- Recommended dose of NPK + FYM T_6- Recommended dose of P through NPS 1# T_7- Recommended dose of P through NPS 2# T_8- Recommended dose of P through NPSZn # T_9- Recommended dose of NPK + Sulphur and Zn equivalent to NPSZn supplied in T_8

Evaluation of different potassic fertilizers in sugarcane

Field experiment was carried out with objective to evaluate different potassic fertilizers in plant and ratoon crop of sugarcane. Ratoon crop were taken up to study the carryover effect of potassic fertilizers directly applied to plant crop. Experimental findings revealed that potassic fertilizers containing elemental sulphur appeared to be better than the others for getting higher sugarcane and sugar yield. Potassium as sulphate of potash (SOP) recorded significantly higher plant cane yield and was at par with potassium ammonium sulphate, MOP + Sulphur @ 40 kg/ha and slow release potash fertilizer in plant crop. The yield of succeeding ratoon crop varied from 93.3 to 108.3 t/ha among different treatments. The ratoon crop yield did not differ significantly, indicating no residual benefit on succeeding ratoon crop (Table 2.5). However, higher ratoon crop yield (108.3 t/ha) was recorded with potassium ammonium sulphate, closely followed by slow release potash fertilizer (105.2 t/ha) and least by MOP + Sulphur @ 40 kg/ha (93.3 t/ha). T4 (slow release potash fertilizer + NPK) appeared better as it performed well in all the parameters.

Crop management for enhancing cane productivity and profitability

Validation of cane node technology at farmers' field

Experimental results indicated that on an average, formation of tillers and millable canes obtained under cane node planting were numerically higher as compared to conventional method of 3 bud sett planting at all the farmers' fields of different sugar factory zones of Uttar Pradesh. Germination per cent, tillers and millable cane numbers recorded under cane node and conventional methods of planting were 68.10% & 41.45%; 89.57% & 40.94% ; 84.98% & 40.16% , 106 & 100 (000/ha); 190 & 170 (000/ha), 200 & 201 (000/ha) and 83 & 75 (000/ha); 123 & 112 (000/ha); 131 & 126 (000/ha) in East, Central and Western sugar factory zones, respectively. Mean values of all the above characters for three sugar factory zones clearly indicated that number of tillers and population of millable canes under cane node planting were higher to the tune of 4.85% and 7.14%, respectively over conventional method. Cane yield obtained at farmers' fields of all the three sugar factory zones exhibited almost similar trend in germination %, tillers and millable cane

Table 2.5. Effect of residual effect of potassic fertilizers on yield and quality of sugarcane ratoon crop

Treatment details	NMC (000/ha)	Cane dia (cm)	No. of internode/ cane	Cane height (cm)	Single cane wt (g)	Yield (t/ha)	CCS (%)
T_1 Potassium Nitrate (13.5:0:46:0) and recommended doses of NPK	139.4	1.97	21.0	291.6	1084.3	102.4	9.73
T_2 Potassium Ammonium Sulphate (9:0:30:20) and recommended doses of NPK	144.1	2.03	23.0	300.0	1288.3	108.3	10.93
T_3 Potassium Ammonium Phosphate (9:46:30:0) and recommended doses of NK and P @ 92 kg/ha	136.3	2.03	22.6	283.3	914.3	100.2	10.75
T_4 Slow release potash fertilizer (0:0:45:0) and recommended doses of NPK	142.8	2.17	23.0	305.0	1083.0	105.2	11.25
T_5 Sulphate of Potash fertilizer (0:0:50:17.5) and recommended doses of NPK	138.2	2.07	21.3	290.0	1049.6	102.2	10.98
T_6 Muriate of Potash (MOP) (0:0:60:0) and recommended doses of NPK	140.9	1.90	20.3	300.0	1094.6	102.6	10.91
T_7 Muriate of Potash (MOP) (0:0:60:0) + Elemental sulphur @ 40kg/ha and recommended doses of NPK	126.9	1.90	19.6	275.0	805.0	93.3	9.35
T_8 Muriate of Potash (MOP) (0:0:60:0) + P @ 92 kg/ha and recommended doses of NK	132.0	1.93	20.3	273.3	876.33	95.9	9.54
CD at 5%	NS	NS	NS	12.475	173.68	NS	NS

numbers. On an average, the cane yield of 88.03 t/ha was obtained which was 8.75% higher than that of conventional method of planting (80.33 t/ha). The technology of sugarcane planting by cane node method also saves precious seed cane and thereby reduces cost of cultivation.

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

Autumn planted sugarcane based systems

During the autumn season, thirteen cropping systems viz. Sugarcane var. CoPk 05191 (Sole), Sugarcane + Potato (Kufri Chandramukhi), Sugarcane + Pea (Azad P-3), Sugarcane + Maize (VMH-174), Sugarcane + Frenchbean (Arun), Sugarcane + Broadbean (SWS 1 White), Sugarcane + Fenugreek (Rajendra Kranti), Sugarcane + Garlic (Polish White), Sugarcane + Coriander (CO.2), Sugarcane + Lentil (PL 639), Sugarcane + Turnip (Purple Top Sultan), Sugarcane + Radish (Clear White), Sugarcane + Sugarbeet (LS-6) were evaluated for their respective yields and economic gains. It is evident from the result that intercropping of autumn sugarcane + garlic fetched the highest net income of ₹ 5,87,605 (Fig. 2.3a and 2.3b). The next best treatment was observed to be Sugarcane + Fenugreek (net income ₹ 5,72,286/ha). The other intercropping systems found highly remunerative were Sugarcane + Coriander (net income ₹ 4,79,325./ha), Sugarcane + Frenchbean (net income ₹ 3,53,231/ha) and Sugarcane + Maize (net income ₹ 3,59,853 /ha). However, the net income from sole sugarcane was obtained only to the tune of ₹ 166847/ha. The results clearly indicate that autumn sugarcane based intercropping systems hold promise in increasing the net income of 2-3 times as compared to the sole sugarcane. The above systems also gave for the higher cane equivalent ratio (121.6 to 247.1 t/ha) and B: C Ratio (2.60 to 4.64).

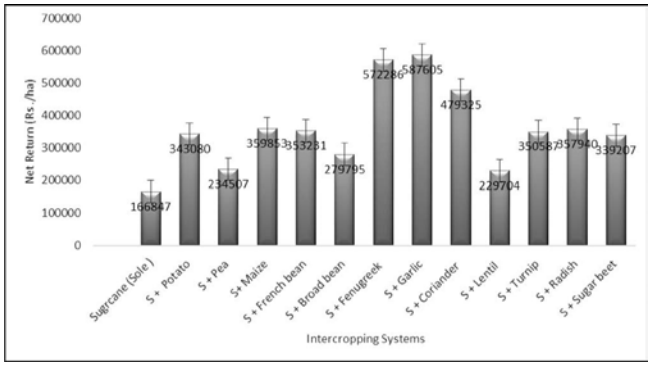

Fig. 2.3a. Net return (₹/ha) of autumn sugarcane based intercropping systems

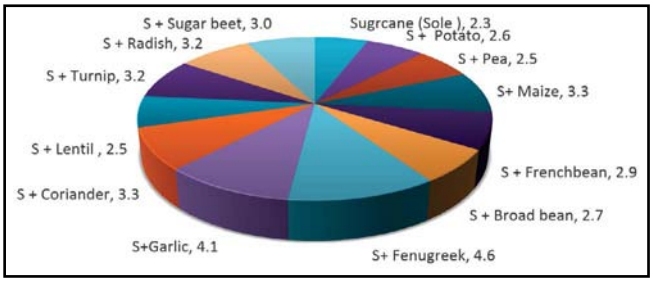

Fig 2.3b. Benefit cost ratio of autumn sugarcane based intercropping system

Spring planted sugarcane based systems

Spring season experimentation also comprised of thirteen cropping systems viz., Sugarcane var. CoPK 05191 (Sole), Sugarcane + Bitter gourd (F1 Hybrid), Sugarcane + Bottle gourd (Shakti 201), Sugarcane + Sponge gourd (Shakti 801), Sugarcane + Pumpkin (Chakor), Sugarcane + Cucumber (Rohini), Sugarcane + Ladies finger (Sunanda), Sugarcane + Cowpea (Chitra Lobia), Sugarcane + Greengram (Virat), Sugarcane + Blackgram (Urd Black Classic), Sugarcane + Sunflower (Sunlight), Sugarcane + Maize (VMH-150), Sugarcane + Onion (Agri-Found Light Red) were tested and respective yields and economic gains were analysed. Spring Sugarcane + Onion recorded the highest net income of ₹ 4,29,312/ ha (Fig. 2.4a and 2.4b). The next best treatments were observed to be Sugarcane + Maize (net income

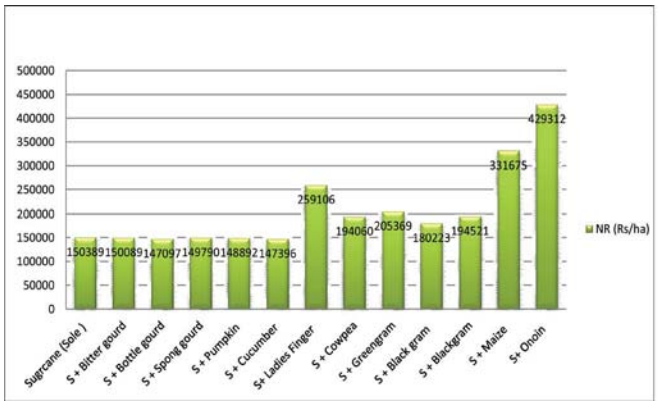

Fig 2.4a. Net return (₹/ha) of spring sugarcane based intercropping systems

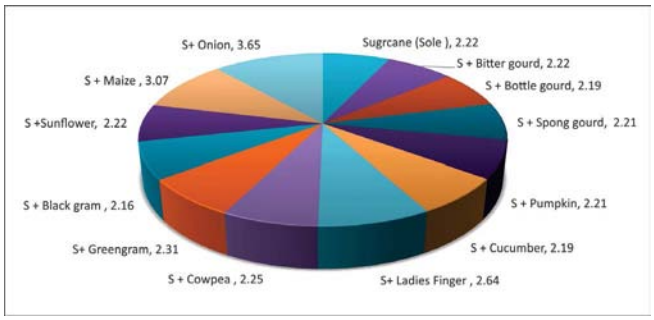

Fig. 2.4b. Benefit cost ratio of spring sugarcane based intercropping system

₹ 3,31,675/ha), Sugarcane + Ladies finger (net income ₹ 2,59,106/ha), Sugarcane + Greengram (net income ₹ 205369/ha). The net income from sole sugarcane was ₹ 1,50,389/ha. Spring sugarcane based intercropping systems also hold promise in increasing the net income as compared to sole sugarcane. The above systems were also recorded for higher cane equivalent ratio (110.7-187.7 t/ha) and B: C Ratio (2.22 to 3.65).

Effect of tillage and management practices on rice - wheat - sugarcane - ratoon - wheat under Conservation Agriculture (CA) system

A field experiment was conducted to assess the effect of tillage and different management practices on the productivity and profitability of sugarcane based production system and on soil quality parameters under conservation agriculture. The trial was initiated during June 2017 with sowing of dry direct seeded rice (DSR) cv. NDR 97 followed by sowing of wheat crop cv. PBW 343 during November 2017. The experiment comprised of two tillage practices and two residue management as main-plot treatments and in sub plot, two treatments viz., with and without brown manuring and in sub-sub plot, three treatments viz. recommended dose of nitrogen (100% RDN); 75% of RDN and 125% of RDN. Findings revealed that the rice grain yield varied from 32.14 to 42.04 q/ha under different treatments. Brown manuring treatment recorded 10.46 per cent higher rice grain yield as against without brown manuring. However, tillage practices did not influence the rice grain yield.

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

Ipomoea is an important binding weed of sugarcane which is difficult to manage. To control the binding weeds, a sound understanding of its biology and growth behaviour is essential. During this period, one pot experiment with *Ipomoea* was taken up.

Plant height recorded at different intervals shows that there was significant changes in plant height at 30 days after sowing (DAS) and at harvest, while at remaining intervals, it was non-significant (Table 2.6).

Plant density significantly affected the root length. Initially root length increased with increase in the plant population but at later stages, it was reversed (Table 2.6). At 60 DAS, significantly higher root length was recorded with pot containing two plants/pot than one, four, five and six plants/pot. At 120 DAS, one plant/pot gave maximum root length.

The highest dry matter accumulation was recorded in single plant/pot at 30, 60 DAS and at harvest than the remaining treatments, while it was the highest in two plants/pot at 90 and 120 DAS.

Table 2.6. Effect of plant density on plant height, leaf area, dry matter accumulation and root length of *Ipomoea spp.*

Plants/ pot	Plant height at 120 DAS (cm)	Leaf area at 120 DAS (cm^2)	Dry matter accumulation at 120 DAS (g/plant)	Root length (cm)
1	205.3	1,178.3	20.8	62.7
2	208.6	1,044.4	23.4	48.9
3	213.0	671.4	15.077	35.2
4	197.7	872.6	11.230	37.9
5	207.1	529.4	8.843	33.6
6	222.9	676.9	6.733	27.3
C.D.	N/A	N/A	7.155	12.3
SE(m)	12.3	192.4	2.297	3.9
SE(d)	17.4	272.1	3.248	5.6
C.V.	10.2	40.2	27.714	16.7

Table 2.7. Effect of depth of sowing on plant height, leaf area, dry matter accumulation and root length of *Ipomoea spp.*

Depth of Sowing (cm)	Plant height at 90 DAS (cm)	Leaf area at 90 DAS (cm^2)	Dry matter accumulation at 90 DAS (g)	Root length 90 DAS (cm)
5.0	210.4	543.2	6.7	23.6
7.5	249.1	520.1	4.9	25.5
10.0	224.1	424.9	5.8	26.3
C.D.	N/A	N/A	N/A	N/A
SE(m)	8.8	63.7	0.5	2.6
SE(d)	12.5	90.1	0.7	3.6
C.V.	6.7	22.2	14.7	17.8

The depth of sowing did not affect plant height at all stages of growth (Table 2.7). Depth of sowing of *Ipomoea* did not have much effect on dry matter accumulation during entire growing period. It significantly affected in the initial stage (30 DAS) while at rest of growing stages, it was non-significant. Moreover, it was observed that the seed sown at lesser (5 cm) depth recorded higher biomass accumulation.

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

The experiment was initiated during February 2017 with paired row planting of sugarcane in trenches. The fertigation of variable amount of N, P and K are

being done as per schedule and the observations on plant germination were recorded. In the drip fertigated treatment, sugarcane germinated earlier and apparently appeared more vigorous than the conventional methods of planting. The initial observation showed that due to limited wetting area under the drip-fertigation, the weed infestation was less in the inter paired row space as compared to conventional methods.

Scheduling irrigation with mulch under different sugarcane planting methods

A field experiment was initiated during second week of February 2017 with aim to enhance crop productivity and water use efficiency in sugarcane. The experiment comprising twelve treatment combinations was laid out in split plot design with four replications. Results revealed that cane yield varied significantly due to different planting methods (Table 2.8). Sugarcane yield (114.3 t/ha) under paired-row trench planting with trash mulching was significantly higher than conventional flat method of planting along with trash mulching (101.9 t/ha). Number of millable canes were higher with paired-row planting with trash mulching (106.0 x 000/ha) and conventional flat method of planting with trash mulching (108.6 x 000/ha) than no mulch treatments (102.4 and 103.2 x 000's/ha, respectively), however, non-significant. The quality parameters like °brix, sucrose content and purity per cent did not differ statistically. The trash application had significant effect on sugarcane yield under different irrigation scheduling. However, irrigation schedules did not influence the cane yield significantly, but the irrigation at IW:CPE 0.8 recorded 7.5 and 1.4 per cent higher cane yield compared to 0.6 and 1.0 IW : CPE ratio, respectively. The WUE was found maximum under paired-row trench planting with trash mulching (0.982 t/ha cm) followed by conventional flat method of planting with trash mulching (0.877 t/ha cm) and paired-row trench planting (0.845 t/ha cm). The cane yield and water use efficiency can be increased significantly by trash mulching.

Evaluation of agronomic performance of elite sugarcane genotype (early) at wider spacing and higher fertility level

Agronomic performance of new sets of elite genotypes (early) of sugarcane (Co 12027, CoLk 12203 and CoPant 12221) along with CoJ 64 and Co 0238 as zonal check at two row spacings viz., 90 and 120 cm as well as at higher fertilizer level (25% higher over recommended doses) of NPK/ha was done. The performance of all the genotypes with respect to plant growth, yield parameters, cane and sugar yields were poor at 120 cm spacing as compared to 90 cm spacing. Germination % recorded at 45 days after planting (DAP) revealed that spacing in planting did not influence the germination of different genotypes. The highest tillers and NMC were registered with genotype CoLk 12203 and CoPant 12221, respectively over rest of the genotypes including zonal check varieties (The lowest was with Co 0238). However, the highest stalk length (232 and 220 cm), single cane weight (0.91 and 0.92 kg), cane yield (102 and 84.3 t/ha) and sugar yield (11.8 and

Table 2.8. Effect of planting methods under different irrigation level on growth, yield, WUE and juice quality of sugarcane

Treatment	Germination (%) (45 DAP)	NMC ('000/ha)	Total water applied (cm)	Cane yield (t/ha)	WUE (t/ha-cm)	Juice quality parameters		
						° Brix	Sucrose (%)	Purity (%)
Planting method								
Conventional flat + no mulch (75 cm row spacing)	33.24	103.2	116.3	95.926	0.825	20.38	18.14	88.47
Conventional flat + trash mulch (75 cm row spacing)	33.76	108.6	116.3	101.993	0.877	20.44	18.10	88.57
Paired-row trench planting + no mulch (30:120 cm row spacing)	33.20	102.4	116.3	98.287	0.845	20.52	18.04	88.41
Paired-row trench planting + trash mulch (30:120 cm row spacing)	32.90	106.0	116.3	114.259	0.982	19.83	17.76	87.34
CD (P=0.05)	NS	NS	-	11.986	-	NS	NS	NS
Irrigation Schedule (IW : CPE)								
0. 60	33.02	105.6	103.8	98.195	0.946	20.21	17.71	87.54
0.80	33.44	105.8	118.8	105.556	0.889	20.29	17.87	88.06
1.00	33.34	103.8	126.3	104.097	0.824	20.22	17.69	87.49
CD (P=0.05)	NS	NS	-	NS	-	NS	NS	NS

DAP: Days after planting, WUE : Water use efficiency, Water applied -116.3 cm; Effective rain-73.8 cm ;
Irrigation water applied - 0.60 IW : CPE= 30 cm; 0.80 IW : CPE= 45.0 cm; 1.0 IW : CPE= 52.5 cm

9.7 t/ha at 10-month stage) was recorded with CoLk 12203 at 90 and 120 cm spacing, respectively. The lowest cane (60 and 52 t/ha) and sugar (7.2 and 6.8 t/ha) yield at both the spacings, respectively was recorded with CoJ 64. The higher cane yield in CoLk 12203 was mainly attributed to its higher single cane weight which was significantly superior to all other genotypes. So far juice quality parameters are concerned, higher brix, sucrose and CCS per cent was registered with Co 0238 and CoJ 64. Co 12027 and CoPant 12221 were superior to CoLk 12203 in respect to the juice quality parameters.

Evaluation of elite genotypes of sugarcane (mid-late) at higher fertility levels and at higher spacing

The performance of nine genotypes of sugarcane (mid-late) viz. CoS 767, Co 12029, CoLk 12205, CoS 12232, Co Pant 97222, CoPb 12211, CoS 8436, Co Pant 12226, Co Pant 12263 at higher fertility level and at two row spacing was evaluated. The results showed that germination % in genotype Co12029 was at par with CoLk 12205, CoPb 12211 and CoS 767 but it was significantly higher over CoS 8436, CoS 12232, Co Pant 97222, CoPant 12226 and CoH 12263. Higher number of tillers were observed in CoS 767, Co 12029, CoLk 12205, Co Pant 12226, Co Pant 97222, CoPb 12211 at 120 and 150 DAP. Tillers number were lower in CoS 8436 planted at 120 cm row spacing. The data on NMC/ ha showed significantly higher values for CoLk 12205, CoS 767, Co 12029, Co Pant 97222 and CoPb 12211 over CoS 8436 and CoH 12263. Co Pant 97222 gave significantly higher yield (115 t/ha) followed by CoLk 12205 (104.32 t/ha) at 90 cm row spacing. Irrespective of the varieties tested, most of the growth parameters viz., tillers number, shoot number, NMC and yield were higher at 90 cm. Germination % was non-significant at both the spacings. Extent of reduction in different growth parameters at 120 cm spacing varied among genotypes. Higher brix containing varieties were Co Pant 12226, Co Pant 97222, Co 12029, CoLk 12205 and CoS 8436. Co Pant 97222 registered higher sucrose% (17.25) at 10 month whereas CoS 12232 attained higher value (19.67%) at 12 month stage. CoS 767 was the poorest in sucrose at both the stages. At 90 cm, Co Pant 97222 gave the highest CCS (t/ha) but was at par with CoLk 12205 (at both spacings), CoPb 12211 (at 120 cm spacing); CoPant 12226 and CoH 12263 (at 90 cm spacing).

ICAR funded Agri-Consortia Research Programme on Water

The experimental crop for the second year was planted in the third week of February, 2017 in split plot design. The experiment was carried out in two sub experiments- one with early maturing varieties and another with mid-late maturing varieties. In all, eight early maturing varieties and eight mid-late maturing varieties were taken up for experimentation. The crop was furrow irrigated with the amount of water equal to 100% (M1) and 75% (M2) of crop water requirement at 40% (S1) and 70% (S2) depletion of soil moisture.

Tillering pattern, NMC and yield

It was observed that tillering in the early maturing varieties started earlier. Number of tillers in early maturing varieties were higher than mid-late maturing varieties at any point of time. In both the variety groups, tiller mortality started after 150 days after planting (DAP). It was 8.11% in early maturing group and 9.52% in late-maturing group between 150 to 180 DAP. In early maturing varieties, tiller population was higher when irrigation water was equal to 100% crop water requirement and applied at 40% depletion of soil moisture followed by irrigation water was equal to 75% crop water requirement and applied at 40% depletion of soil moisture.

Different varieties behaved differently under different irrigation treatments (Table 2.9). The highest number of millable canes was observed in M2S1 treatment. Maximum NMC was observed in M2S2 treatment for early maturing varieties and in M1S2 treatment for late maturing varieties. The highest NMC were observed in CoPK 05191 in early maturing and Co 05011 in late maturing variety groups (Table 2.10).

Irrigation treatments and varieties both influenced sugarcane yield (Table 2.9 and Table 2.10). The highest sugarcane yield was observed in M2S1 and the lowest was in M2S2 for both the variety groups. In early maturing variety group, CoPK 05191 yielded the highest whereas in mid-late maturing group, CoS 08279 yielded the highest. The lowest cane yield in early varieties was observed in CoJ 64 whereas in mid-late group, it was observed in CoS 767.

Irrigation water use efficiency

Irrigation water use efficiency (IWUE) has also been influenced by irrigation treatment and sugarcane varieties both. The lowest IWUE has been observed with M1S1 treatment for both the variety groups. However, it was the highest in M2S1 for early maturing varieties and in M1S2 in mid-late maturing varieties. The highest IWUE was observed with CoPK 05191 and CoS 08279 in early and mid-late maturing variety

Table 2.9. Effect of different irrigation treatments on millable canes, sugarcane yield and irrigation water use efficiency

Irrigation treatment	NMC ('000)		Sugarcane yield (t/ha)		Irrigation water use efficiency (kg/ha-cm)	
	Early maturing	Mid-late maturing	Early maturing	Mid-late maturing	Early maturing	Mid-late maturing
M1S1	105.7	95.6	74.8	65.5	582.7	1246.6
M2S1	112.8	97.2	80.6	68.4	644.9	1176.3
M2S2	104.3	94.5	68.6	62.2	605.6	1181.7
M1S2	105.6	94.2	71.7	66.9	598.3	1190.4

Table 2.10. Effect of different sugarcane varieties on millable canes, sugarcane yield and irrigation water use efficiency

Variety	NMC ('000)	Sugarcane yield (t/ha)	Irrigation water use efficiency (kg/ha-cm)	Variety	NMC ('000)	Sugarcane yield (t/ha)	Irrigation water use efficiency (kg/ha-cm)
Early maturing				**Mid-late maturing**			
CoPK 05191	121.7	121.5	998.7	CoS 767	89.5	59.4	598.5
CoJ 64	94.3	49.5	407.0	Co 05011	103.7	64.0	1585.8
CoLk 09202	118.4	86.8	714.5	CoPant 97222	95.3	65.9	966.1
Co 0238	98.3	79.4	652.3	CoPant 5224	88.8	62.9	982.6
CoSe 03234	109.2	71.5	586.3	CoS 08279	97.2	74.6	1285.6
CoLk 94184	115.7	68.4	563.5	CoS 08276	88.4	65.3	1173.6
CoLk 09709	98.6	67.1	551.7	CoS 97261	99.3	66.5	1221.9
CoS 8436	100.4	47.4	389.2	CoSe 01434	100.4	67.5	1776.3

groups, respectively. The IWUE was lowest in CoS 8436 in early maturing group and it was lowest in CoS 767 in mid-late maturing group.

Sustaining sugarcane yield under multiple ratooning through drip irrigation

The experiment was initiated from 4th ratoon. This year 5th 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 fertilizers *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 NMC (106.62 thousand) was recorded in ring-pit planting system (Table 2.11) followed by surface drip irrigated plots where planting of sugarcane was done at 75 cm spacing (T2) (103.04 thousand). The lowest NMC (53.92 thousand) was recorded in surface irrigated crop planted at 90 cm spacing. The highest sugarcane yield (89.72 t/ha) was recorded in ring-pit planting system. The lowest sugarcane yield (44.54 t/ha) was recorded in surface irrigated crop planted at 90 cm spacing. The highest irrigation water use efficiency (1631.3 kg/ha-cm) was recorded in ring-pit planting system. The lowest irrigation water use efficiency (506.1 kg/ha-cm) was recorded in surface irrigated crop. Drip irrigated treatments attained higher leaf area before onset of monsoon and it resulted in higher growth of plants during grand growth season.

Table 2.11. Number of millable canes, sugarcane yield, irrigation water applied and irrigation water use efficiency

Treatment	Leaf area per hectare before onset of monsoon (m^2)	Millable canes ('000)	Yield (t/ha)	IW (mm)	IWUE (kg/ha-cm)
T_1: Planting at 75 cm row to row distance with surface irrigation & recommended fertilizers application in soil	85074.8	62.25	55.58	880.0	615.8
T_2: Planting at 75 cm row to row and at alternate row drip irrigation-fertigation	118914.3	103.04	82.32	550.0	1496.7
T_3: Paired row planting under 40x110x40 cm with drip irrigation-fertigation	114969.2	96.67	77.01	550.0	1347.2
T_4: Paired row planting under 45x135x45 cm with drip irrigation-fertigation	98836.3	87.68	66.71	550.0	1213.0
T_5: Paired row planting under 60x120x60 cm with drip irrigation-fertigation	112284.5	83.99	68.06	550.0	1236.1
T_6: Paired row planting under 40x110x40 cm with sub-surface drip irrigation-fertigation	118787.8	89.22	79.46	550.0	1444.7
T_7: Surface drip in ring-pit planting method (105x75cm) with drip irrigation-fertigation	131539.2	106.62	89.72	550.0	1631.3
T_8: Planting at 90 cm row to row distance with surface irrigation & recommended fertilizers application in soil	68028.9	53.92	44.54	880.0	506.1
SE±	5043.0	1.77	0.74		11.74
CD (P= 0.05)	8880.7	3.11	1.30		20.67

CHAPTER 3

Management of Insect Pests and Diseases

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

Insect pests and disease surveys were conducted in command areas of different sugar mills in Uttar Pradesh, Bihar, Maharashtra and Narsinghpur District of Madhya Pradesh.

In Uttar Pradesh

Sugarcane field in the command areas of Chilbaria Sugar Mill, Nanpara Sugar Mill, Bahraich and Hata Sugar Mill, Deoria; Hata, Bahraich; and Deoria; four units of DSCL Group (Rupapur, Haryawan, Loni, Ajbapur), three units of Balrampur Group, Sekseria Sugar Mill, Biswan, Sitapur; Roja Sugar Works, Roja; K.M. Sugar Mill, Masodha; Oudh Sugar Mill, Hargaon; Dalmia Chini Mill, Ramgarh and IPL Chini Mill were surveyed. The incidence of early shoot borer (35%), root borer (45%), cumulative incidence of top borer (43%) was observed. Army worm is increasing and incidence was around 5% and 5-10%, respectively (Fig. 3.1). Incidence of root borer (20%) and army worm (60%) was observed. Incidence of ESB was 5-15%. A black beetle (*Heteronychus* sp.) was observed gnawing the basal portion of young shoots and causing dead heart. Its occurrence was wide spread in Chilbaria Sugar Mill, Nanpara Sugar Mill, Bahraich and Hata Sugar Mill area.

Mite incidence was observed up to 20.0%. Sporadic incidence of YLD was observed in Co 0238 in Hata area. Low incidence of black bugs was observed in ratoon and plant crops.

Incidence of red rot was noticed at several locations affecting Co 0238 and in certain fields, the incidence was up to 20%. In some old and rejected sugarcane varieties like CoLk 8102, CoSe 92423, CoSe 95422, CoS 95255 and CoS 8436, incidence of red rot was noticed. Incidence of smut was observed in some sugarcane varieties like CoSe 92423, CoS 88230 and Co 0238. About 5% incidence of GSD (Grassy Shoot Disease) was observed in most of the fields. The minor disease *Pokkah boeng* becoming concern in Co 0238 and in many locations, the crop was found badly affected. Incidence of leaf scald was also noticed in some locations.

In Narsinghpur, Madhya Pradesh

Smut, RSD and GSD was observed in Mugli, Mahamadpur, Dangidhana and Kartaj villages in Narsinghpur District. Incidence of early shoot borer and top borer was moderate, while incidence of white fly was higher.

In Bihar

Sugarcane fields were surveyed in the command areas of Vishnu Sugar Mills, Gopalganj; Sasa Musa Sugar Mills, Gopalganj; New Swadeshi Sugar Mills, Narkatiaganj; Harinagar Sugar Mills Limited, Harinagar; Majhauliya Sugar Mills, West Champaran; HPCL Biofuels Ltd., Suaguli, Bihar and Hasanpur Sugar Mills, Hasanpur, Samastipur. CoP 06436, BO 91, BO 154 CoP 9301, Co 0238, CoSe 95422, Co 0118, CoLk

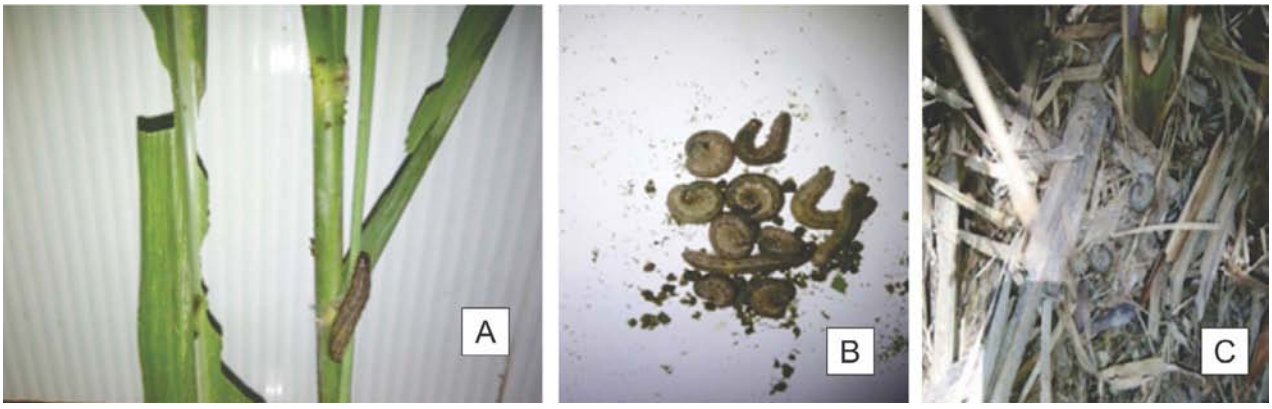

Fig. 3.1. Army worm infestation in sugarcane

A. Typical symptoms of army worm damage and caterpillar
B. Caterpillar of army worm
C. Caterpillars of army worm hiding in leaf trash

94184, Co 0239, BO 130 and CoP 112 were the varieties found in cultivation. Red rot was recorded in varieties namely CoSe 95422, Co 0238, CoP 06436 and BO 130 to the tune of 2-10%. Whereas Pokkah boeng was observed in the variety Co 0238 (10-25%) and Yellow Leaf Disease (YLD) was noticed in the varieties like CoSe 95422, CoP 06436, CoLk 94184, Co 0118, BO 130 and Co 0238.

In Maharashtra

Incidence of white fly (*Aleurolobus barodensis*) was mostly observed in poorly drained fields. During July 2017, the incidence of whitefly was recorded on CoM 265, Co 86032, VSI 8005 and MS 10001 with severe infestation on CoM 265. The most affected villages were Loni (Bk), Loni (Kh), Ashwi, Dadh, Pratappur, Umbri, Chinchpur, Pathare, Kolhar, Fatyabad, Dhanore, Lohgaon, Tijgaon and Hasanapur.

White grubs (*Holotrichia serrata* and *H. consanguinea*) were recorded in Pravarnagar whereas another species *Leucopholis lepidophora* was observed in Sangli and Kolhapur. The pest incidence ranged 30 to 90% in different villages (Rajuri, Mamdapur, Tisgaon, Kolhar, Loni, Chinchpur and Durgapur).

The incidence of early shoot borer ranged from 10–25% in different villages like Pathare, Loni, Rajuri, Dadh, Kolhar, Tijgaon, Chicholi, Ashwi, Lohagaon and Chinchpur. Internode borer (*Chilo sacchariphagus*), Pink borer (*Sesamia inferens*), Woolly aphid (*Ceratovacuna lanigera*), Scale insect (*Melanaspis glomerata*) and Pyrilla (*Pyrilla perpusilla)* were noticed in traces.

Yellow leaf disease (YLD) is coming up in the area as main concern. Incidence of Pokkah boeng, 10-20% in ratoon and 1-5% in plant crops was observed in CoM 265 in Bhableshwar and Kolhar area. Similarly, the incidence of brown spot during the rainy season was recorded in CoM 265 and VSI 8005 at Pravaranagar.

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

Yellow leaf disease (YLD) is caused by both phytophasma and virus. YLD infected cane of CoLk 94184 was treated with five combination of heat treatments in MHAT unit. The treatments were T_1= 2h first day +2h second day +2h third day of MHAT at 50^{0}C; T_2= 2h first day +1h second day +1h third day of MHAT at 50^{0}C; T_3= 2h first day +2h second day +1h third day of MHAT at 50^{0}C; T_4= 1h first day +1h second day +1h third day and T_5= Normal MHAT (54^{0}C for 2 h 30 min) along with two controls (C_1: Healthy seed cane; C_2: Diseased seed cane). Observations were taken after 50 days intervals till harvest of the crop. Molecular detection was also tried at 150 days old crop.

Results revealed that none of the treatments along with control expressed YLD syptoms up to crop age of 150 days. Appearance of YLD symptoms was noticed first at 200 days old crop with 11 plants of T_4 and 15 plants in C_2. At the age of 250 days old crop, T_2, T_4, C_1 and C_2 recorded YLD infection in 14, 13, 7 and 25 plants, respectively. At the age of 300 days old crop, T_2, T_3, T_4, C_1 and C_2 recorded YLD infection in 24, 17, 21, 18 and 34 plants, respectively. Rest of the treatments were symptomless.

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

During 2017-18 crop season, 56 genotypes viz., LG 14455, LG 13414, LG 14540, LG 13405, LG 13444, LG 13452, LG 12481, LG 14551, LG 13431, LG 13466, LG 14554, LG 13447, LG 13439, LG 14492, LG 13416, LG 12480, LG 14508, LG 12429, B-4-8, LG 11602, LG 11601, D-1-3, B-2-3, LG 11603, LG 07645, LG 11543, LG 11406, LG 11517, E-171, D-11, LG 12478, LG 13435, LG 12426, LG 11528, LG 14537, LG 11412, D-5-10, LG 12022, LG 11706, LG 12040, LG 11158, LG 12061, LG 12042, LG 12032, LG 12035, LG 11084, LG 12028, LG 12081, LG 11096, LG 12027, LG 12007, LG 11091, LG 11212, LG 11067, LG 10726 and LG 10723 were evaluated for their performance against *C. falcatum* pathotypes Cf 08 & Cf 09 and smut.

Eleven genotypes were rated R, 35 were MR and rest 10 genotypes were susceptible (MS to HS) against the pathotype Cf 08. The virulence level of Cf 09 was not found upto the mark in CoS 767, hence, result is subject to further verification.

Out of fifty six genotypes evaluated against smut, 32 genotypes did not produce any smut whip and were rated as tolerant/resistant. Rest 24 were susceptible to smut infection (produced MS/S grade of reaction).

Natural incidence of wilt was observed in 14 genotypes viz., LG 13414, LG 12481, LG 14554, LG 14492, LG 11602, LG 11601, B-2-3, LG 11543, LG 12478, LG 14537, LG 11412, LG 11158, LG 12081 and LG 11091 whereas remaining 42 were free from wilt.

Enhancing efficacy of *Trichoderma* based red rot management system

One hundred three *Trichoderma* isolates, established previously from sugarcane rhizosphere leaf, stalk and root tissues were screened for production of ammonia, catalase and Indole acetic acid (IAA) as well as for their phosphate and zinc mineralization potential *in vitro*. Twenty isolates exhibited high

minerlizing potential; eight isolates from sugarcane rhizosphere (STr-1, 3, 64, 83, 93, 120, 123 & 126), eight isolates from root tissue (SER-1, 10, 18, 20, 25, 35, 39 & 43), two isolates from stalk tissue (SES-10 & 11) and two isolates from leaf tissue (SEL-5 & 6) of sugarcane.

Field experiments were carried out to standardize the delivery system for application of *Trichoderma* isolates for red rot management. Three-bud setts of variety Co 1148, previously inoculated with *C. falcatum* (Cf 01) by sett-dip method (10^4 spores/ml) were used in the study. Two most promising *Trichoderma* isolates (STr-83 & 108) were selected and their talc based formulations were prepared. The isolates were applied as soil application alone, as combination of sett treatment + soil application through FYM at the time of planting and as combination of sett treatment + soil application at planting + at 45 and 90 days after planting. All treatments showed considerable reduction (35.3 to 52.9%) in red rot induced bud mortality over control. The highest reduction in red rot (52.9%) was recorded in sett treatment + single soil application of STr-108 at the time of planting. Most treatments also showed significantly higher yields relative to inoculated control (60.3 to 66.9 t/ha in different treatments as compared to 50.6t/ha in control).

Mechanism of resistance against top borer of sugarcane

Nine sugarcane varieties viz., CoS 94257, CoSe 92423, CoPant 97222, CoS 96268, CoS 767, Co 0238, CoLk 94184, CoJ 64, CoLk 8102 were planted under RBD in the experimental farm of the Institute. Based on the observations made on per cent top borer incidence, five varieties viz., CoS 94257, CoS 767, CoPant 97222, CoS 96268 and CoSe 92423 were graded less susceptible, while four varieties viz., CoLk 8102, Co 0238, CoJ 64, CoLk 94184 were graded as susceptible to the borer.

Observations were taken on morphological characters of the sugarcane genotypes such as length, width, inclination, hairiness of leaf and thickness of midrib, leaf sheath, plant height and biochemical characters such as poly phenol oxidase activity, phenol content, reducing sugar at the initiation of 3rd brood of top borer. Amongst all the morphological characters recorded, leaf width showed a positive correlation (r=0.742) with top borer incidence. Similarly, the top borer incidence was negetively influenced by midrib thickness (r= -0.743) and plant height (r= -0.677). Amongst the biochemical parameters, reducing sugar was positively correlated (r=0.778) while poly-phenol oxidase (r=-0.681), proteinase inhibitor activity (r=-0.798) and total phenol (r=-0.751) were negatively correlated with the incidence of top borer.

Containment of major insect-pests of sugarcane through habitat modifications

The incidence of top borer (III and IV brood) ranged 17-41- 21.53% and 21.12-24.84%, respectively in plots along with various trap crops as compared to no trap crop (24.52 and 39.85%). The minimum incidence of III and IV brood was recorded in plots along with sorghum, maize and brinjal. The incidence of top borer (V brood) was also low in plots along with various trap crops (7.69 -11.74%).

Internode borer incidence was recorded minimum in brinjal (12.42%) followed by maize, *sorghum* and marigold (13-14%) plots along with sole sugarcane (23.74%). The population of egg parasitoids (*Trichogramma chilonis* and *Telenomus* spp.) and larval parasitoids (*Rhaconotus scirpophagae, Isotima javensis*, *Stenobracon nicevillei* and *Cotesia flavipes*) were more in plots along with various trap crops than sugarcane sole crop. The parasitisation of top borer larvae (IV brood) by *Rhaconotus scirpophagae, Isotima javensis* and *Stenobracon nicevillei* was 29-45% in plots along with various trap crops as compared to sugarcane sole crop (22.31%). Larval parasitoid, *Cotesia flavipes* parasitized 15.13-22.87% larvae of internode borer in various trap crops. *Cotesia flavipes* was more active in the field (along with sorghum, tomato, brinjal and maize) for its parasitisation which resulted a reduction in the incidence of internode borer.

AICRP (S) Trials

Identification of pathotypes in red rot pathogen

During 2017-18, fifteen new *Colletotrichum falcatum* isolates viz., two isolates from CoS 8436 (IR-145 and IR-146); three isolates from CoSe 95422 (IR-147, IR-148 and IR-152); two isolates from CoS 767 (IR-153 and IR-154); six isolates from Co 0238 (IR-140, IR-141, IR- 143, IR-149 IR-150 and IR-151); and one isolate each from CoS 92423 (IR-144) and CoLk 8102 (IR-142) were evaluated for their virulence on 14 designated differentials viz., Co 419, Co 975, Co 997, Co 1148, Co 7717, Co 62399, CoC 671, CoJ 64, CoS 767, CoS 8436, BO 91, Baragua (*S. officinarum*), Khakai (*S. sinense*), and SES-594 (*S. spontaneum*) using standard plug method of inoculation. Except the isolates obtained from Co 0238, the virulence pattern of other isolates were more or less matched with the existing pathotypes of this zone. It was observed that Co 0238 isolates have specific virulence for Co 419, intermediate virulence for CoC 671 and no virulence against Co 997. In addition, isolates of Co 0238 have shown intermediate virulence against BO 91 but virulence to Co 62399 and CoS 8436. Thus,

indicating the development of a new specific virulence (though has lower spectrum of overall virulence) at this area that is capable of knocking down the popular variety Co 0238.

As decided, five sugarcane varieties viz., CoSe 95422, Co 7805, Co 86002, Co 86032 and CoV 92102, were multiplied in this season for their use as differential.

Evaluation of zonal varieties against red rot, smut and wilt

A. Location: IISR, Lucknow (North West Zone)

Forty one genotypes *i.e.* eight entries IVT (Early) viz., Co 14034, CoLk 14201, CoLk 14202, CoPant 14221, CoPant 14222, CoPb 14181, CoPb 14182 and CoPb 14211; fifteen IVT (Mid late) viz., Co 14035, CoH 14261, CoH 14262, CoLk 14203, CoLk 14204, CoLk 14205, CoPb 14183, CoPb 14184, CoPb 14185, CoPb 14212, CoS 14231, CoS 14232, CoS 14233, CoPant 97222 and Co 05011; three AVT (Early)-I Plant viz., Co 13034, CoPb 13181 and CoS 13231; four AVT (Early)-II Plant viz., Co 12026, Co 12027, CoLk 12203 and CoPant 12221; five AVT (Mid late)-I Plant viz., Co 13035, CoH 13263, CoLk 13204, CoPant 13224 and CoPb 13182; six AVT (Mid late)-II Plant viz., Co 12029, CoH 12263, CoLk 12205, CoPant 12226, CoPb 12211 and CoS 12232 were raised and evaluated against red rot, smut through artificial inoculation and against natural incidence of wilt and yellow leaf disease. Respective susceptible checks were also maintained viz., CoJ 64 (Cf 08) and CoS 767 (Cf 09) for the pathotypes of red rot and CoLk 7701 and Co 1158 for the smut.

(i) Red rot

As per technical programme of AICRP(S), inoculation of red rot was carried out using both plug and nodal methods of inoculation. The cane stalks were split open longitudinally after 60 days of inoculation and observation on the development of red rot was recorded on 0-9 scale.

In IVT (Early), two genotypes viz., Co 14034 and CoLk 14202 was found R and five genotypes viz., CoLk 14201, CoPant 14221, CoPant 14222, CoPb 14181 and CoPb 14182 were found MR against both the pathotypes (Cf 08 and Cf 09). CoPb 14211 was MS against pathotype Cf 08 and MR against Cf 09.

In AVT (Early)–I Plant, two genotypes viz., Co 13034 and CoPb 13181 were found MR by plug method against both the pathotypes (Cf 08 and Cf 09). CoS 13231 was MR against Cf 08, whereas S to Cf 09.

In AVT (Early)-II Plant, Co 12027 was R and CoLk 12203 was MR against both the pathotypes. Whereas, CoPant 12221 was MS and Co 12026 was S against both the pathotypes.

In IVT (Mid late), out of 15 genotypes evaluated, CoLk 14205 was R and thirteen genotypes viz., Co 14035, Co 05011, CoH 14261, CoH 14262, CoLk 14203, CoPant 97222, CoLk 14204, CoPb 14183, CoPb 14184, CoPb 14185, CoPb 14212, CoS 14232 and CoS 14233 were MR against both the pathotypes. Only CoS 14231 was found S to both the pathotypes.

In AVT (Mid late)-I Plant, all the five genotypes viz., Co 13035, CoH 13263, CoLk 13204, CoPant 13224 and CoPb 13182 were rated as MR against both the pathotypes.

In AVT (Mid late)-II Plant, four genotypes viz., Co 12029, CoH 12263, CoLk 12205, and CoS 12232 were found MR and two genotypes viz., CoPant 12226 and CoPb 12211 were MS to both the pathotypes (Cf 08 and Cf 09).

(ii) Smut

As per the technical programme, sett-dip inoculation was carried out at the time of planting. 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 till harvest of the crop.

Out of 41 genotypes tested, 15 genotypes viz., CoLk 14201, CoPant 14221, Co 13034, CoPb 13181, Co 12026, CoLk 12203, CoH 14261, CoH 14262, CoLk 14203, Co 05011, Co 13035, CoH 13263, CoPant 13224, CoH 12263 and CoS 12232 were graded as R. Nine genotypes viz., CoPant 14222, CoPb 14182, Co 12027, CoPb 14184, CoPb 14185, CoPant 97222, CoLk 13204, CoPb 13182 and CoLk 12205 were rated as MR. Twelve genotypes namely Co 14034, CoLk 14202, CoPb 14181, Co 14035, CoLk 14204, CoLk 14205, CoPb 14212, CoS 14231, CoS 14233, Co 12029, CoPant 12226 and CoPb 12211 were rated as MS and rest five genotypes viz., CoPb 14211, CoS 13231, CoPant 12221, CoPb 14183 and CoS 14232 were rated susceptible (S) to smut.

(iii) Wilt

Out of 41 genotypes, in 12 genotypes viz., Co 05011, Co 14034, CoLk 13204, CoLk 14205, CoPant 14222, CoPb 13182, CoPb 14182, CoPb 14185, CoPb 14211, CoPb 14212, CoS 14231 and CoS 14232 natural incidence of wilt was observed.

(iv) Yellow leaf disease (YLD)

Natural incidence of Yellow leaf disease (YLD) was also observed in four genotypes viz., CoPb 14182, CoPb 14185, CoPb 14212 and Co 13035.

B. Location: IISR Regional Station, Motipur, Bihar (North Central Zone)

In North Central Zone, 27 genotypes were screened against red rot at IISR RC, Motipur. Eight IVT (Early) viz., CoBln 14501, CoLk 14206, CoLk 14207, CoP 14436, CoP 14437, CoSe 14451, CoSe 14453 and CoSe 14454; three AVT (Early)-I Plant viz., CoP 13437, CoSe 13451 and CoSe 13452; three AVT (Early)-II Plant viz., CoLk 12207, CoP 12436 and CoSe 12451; nine IVT (Mid late) viz., CoBln 14502, CoLk 14208, CoLk 14209, CoLk 14210, CoP 14438, CoP 14439, CoSe 14452, CoSe 14455 and CoSe 14456; four AVT (Mid late)-II Plant viz., CoLk 09204, CoLk 12209, CoP 12438 and CoSe 12453 along with seven standard checks were evaluated against two pathotypes (Cf 07 and Cf 08) of *C. falcatum*.

(i) Red rot

In IVT (Early), seven genotypes viz., CoBln 14501, CoLk 14206, CoLk 14207, CoP 14436, CoP 14437, CoSe 14451 and CoSe 14453 were rated as MR and one genotype, CoP 14437 was MS to both the pathotypes (Cf 07 and Cf 08). CoSe 14454 was MR against Cf 07 and MS against Cf 08.

In AVT (Early)-I Plant, CoSe 13452 was rated as R against both the pathotypes. CoSe 13451 was MR whereas, CoP 13437 was MS to both the pathotypes.

In AVT (Early)-II Plant, two genotypes CoLk 12207 and CoSe 12451 were MR against Cf 07 and Cf 08. Genotype CoP 12436 was MR against Cf 07 and S to Cf 08.

In IVT (Mid late), eight genotypes were tested. CoLk 14210 was R and CoBln 14502, CoLk 14208, CoLk 14209, CoP 14438, CoP 14439, CoSe 14455 and CoSe 14456 were MR against Cf 07 and Cf 08. CoSe 14452 was rated R against Cf 07 and MR against Cf 08.

In AVT (Mid late)-II Plant, three genotypes namely CoLk 09204, CoLk 12209 and CoP 12438 were MR against Cf 07 and Cf 08. CoSe 12453 was R against Cf 07, whereas MR against Cf 08.

Among the standard checks i.e., CoSe 95422 was susceptible (S) against both the pathotypes. BO 130, CoP 06436 and BO 91 were MR against Cf 07 and Cf 08. CoJ 64, the original host of Cf 07 and Cf 08 gave highly susceptible (HS) reaction.

(ii) Smut

Out of 27 genotypes tested, four genotypes viz., CoLk 14206, CoP 14437, CoP 13437 and CoSe 14451 were rated as susceptible (S); six genotypes viz., CoLk 12207, CoP 12436, CoSe 12451 CoLk 12209, CoP 12438 and CoSe 12453 were rated as MR and rest 17 genotypes were rated as R against smut.

(iii) Wilt

Natural incidence of wilt was observed in eight genotypes viz., CoLk 14207, CoP 14436, CoSe 14451, CoSe 13451, CoSe 12451, CoLk 14209, CoLk 14210 and CoSe 14456.

(iv) Yellow leaf disease (YLD)

Natural incidence of Yellow leaf disease (YLD) was observed in ten genotypes viz., CoBln 14501, CoP 14436, CoP 14437, CoSe 14451, CoSe 13451, CoP 12436, CoLk 14208, CoLk 14210, CoLk 12209 and CoP 12438.

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

During 2017-18 sugarcane crop season, surveys were conducted in command areas of different sugar mills located around the district Lucknow, Uttar Pradesh (Parle Sugar Mills, Parsendhi, Bahraich; IPL Sugar Chemical, Jarwal, Bahraich; Simbhaoli Sugar Mills, Chilwariya, Bahraich; Dalmia Chini Mills, KM Sugar Mills, Masaodha, Faizabad; Balrampur Chini Mills Group located in Balarmpur and Gonda; Chini Mills of DSCL group located in Hardoi and Lakhimpur; Oudh Sugar Mills, Hargaon, Sitapur and Seksaria Chini Mill, Biswan, Sitapur). Incidence of red rot was observed in CoS 8436, CoSe 92423, CoLk 8102, Co 0238 and CoSe 95422. Variety Co 0238 was affected with red rot at several locations in the command areas of different sugar mills and the disease incidence varied from 3 to 20% in the affected cane fields. In some fields of CoSe 95422, CoS 8436, and CoSe 92423 the incidence of red rot was up to 30%.

Incidence of smut was observed at several locations, mostly affecting CoSe 92423, CoS 88230, CoS 91269 and Co 0238 (1-5%).

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 Pokkah boeng was higher in Co 0238. In some fields of Co 0238, Pokkah boeng incidence was more than 30%. Sporadic incidence of leaf scald was also noticed in Co 0238.

Assessment of elite and ISH genotypes for resistance to red rot

The twenty six ISH genotypes namely SA04-472, SA04-454, MA/5/22, MA/5/37, PG 9869137, BM 1009-163, BM1022-173, BA 1003143, SA04-390, SA04-496, CYM-07986, AS04-2097, BM-1009149, AS04-1687, MA5/5, SA98-13, GU07-2276, MA5/51, GU6007-3849, SA04-409, BM1010168, MA5/99, AS04-1689, GU073-774, AS04-635 and AS04-245 were received from ICAR-Sugarcane Breeding Institute, Regional Centre, Karnal,

Haryana during 2017-18 and multiplied. Experiment has been planted in spring season, 2018.

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

In early maturing group, four sugarcane genotypes viz., Co 12027, CoS 13231, CoLk 12203, CoPant 12221 and two standards (Co 0238 and CoJ 64) and in mid-late maturing group, 13 genotypes viz., Co 05011, Co 13035, Co 12263, Co 12029, CoH 13263, CoPb12211, CoPb 13181, CoLk 12205, CoLk 13204, CoS 12232, CoPant 12226, CoPant 13224, and two standards (CoS 767 and CoPant 97222) were planted on February 23, 2017 in plots of 3.6 x 6 m size with 90 cm row to row distance and each treatment was replicated thrice. Recommended agronomic practices were followed to raise a good crop. No insecticide was applied at any stage of the crop.

In early group, incidence of top borer II, III and IV brood was ranged 15.67 to 40.33, 11.29 to 26.37 and 14.35 to 33.33%, respectively. Incidence and intensity of stalk borer borer ranged 3.02 to 9.03 and 0.73 to 4.23%, respectively. Incidence and intensity of internode borer ranged 5.08 to 16.74 and 1.19 to 5.52%, respectively. Infestation index of stalk borer and internode borer ranged from 0.007 to 0.074 and 0.117 to 0.925, respectively.

CoLk 12203 showed MS reaction and rest of the genotypes showed HS (Highly Susceptible) reaction to II brood of top borer. Co12027 genotype showed HS reaction and rests of the genotypes showed MS reaction to top borer III brood. Two genotypes viz., Co 12027 and standard Co 0238 were HS and rests were MS to top borer IV brood. All the genotypes showed LS reaction to internode borer. CoPant 97222 and CoJ 64 were MS and rests were HS to stalk borer. Corrected brix, sucrose percent and purity coefficient ranged from 17.54 to 20.85, 14.26 to 17.97 and 81.31 to 86.71, respectively in November.

In mid-late group, incidence of top borer II, III and IV brood was ranged from 12.05 to 34.44, 6.06 to 22.06 and 9.85 to 46.09%, respectively. Incidence and intensity of internode borer ranged 6.87 to 16.68% and 1.28 to 5.93, respectively. Incidence and intensity of stalk borer ranged from 4.14 to 17.14 and 0.65 to 6.62%, respectively. Infestation index of stalk borer was more than one in CoLk 13204 and infestation index against both the borers in rest of the genotypes was >1.

Seven genotypes viz., CoLk 12205, CoS 12232, Co 13035, CoLk 13204, Co 05011, Co 12263, CoS 8436 were MS and rests were HS to top borer II brood. CoS 12232 was LS and rest genotypes were MS to top borer III brood. Co 05011 was LS to top borer IV brood and MS to II and III brood. Five genotypes viz., CoLk 12205, CoS 12232, CoPb 12211, Co 12263 were MS and rests were HS to top borer IV brood. Corrected brix, sucrose percent and purity coefficient ranged from 16.51 to 19.64, 14.35 to 17.95 and 85.81 to 91.07, respectively in November.

Survey and surveillance of sugarcane insect pests

The survey was conducted in command area of Chilbaria Sugar Mill, Nanpara Sugar Mill, Bahraich and Hata Sugar Mill, Deoria, U.P. The incidence of root borer and army worm is increasing and the incidence was around 5% and 5-10%, respectively with one location a heavy patch incidence of root borer (20%) and army worm (60%) was observed. Incidence of ESB was 5-15%. A black beetle (*Heteronychus* sp.) was observed gnawing the basal portion of young shoots and causing dead heart. Its occurrence was wide spread.

During 2017-18, insect survey was conducted in command areas of USDM, Ltd. Shamli; DSCL Sugar-Hariawan and Loni. The incidence of top borer (II brood), ESB, web mite and white grub was observed as 2-8%, 2-3%, 3-6%, 10-20% and 1-4%, respectively in variety Co 0238 in different villages of USDM, Shamli. White grub (8-10%) was observed in varieties Co 89003, Co 05011 and CoSe 95422 in DSCL-Hariawan and Loni. Low incidence of top borer and stalk borer in Shahjahanpur area was also noticed.

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

Experiment on monitoring of insect pests of sugarcane was carried out with CoLk 94184. Planting was done in February 2017. Recommended agronomic practices were followed to raise a good crop. Periodic observations on incidence of insect pests and parasitoids of pests were recorded. Due to termites, bud damage ranged from 8.33 to 33.33%. Per cent cut end damage of sett was high but in most of the cases, buds were intact. Complete sett damage was 0.5 to 1.5% and live workers were also present (5 to 50 per sett).

Incidence of top borer II, III and IV brood was in the range of 9.01 to 18.85, 10.20 to 19.62 and 14.03 to 23.16%, respectively. Incidence of root borer was 18.18 to 48.00% in July and in the month of September, it was 35.71-62.96%.

Incidence of internode borer was low, while the incidence of stalk borer is on increasing trend. The incidence of *Pyrilla perpusilla* was low and its adult and

nymph parasitoid, *Fulgoraesia* (*Epiricania) melanoleuca* was active. Mealy bug and black bugs were present in every clump. Parasites like *Telenomus beneficiens* (80.0% on egg mass basis). Total parasitisation of top borer was 41.43% - due to *Stenobracon* sp. (5.76%), *Rhaconotus* sp. (8.81%) and *Isotima javensis* (26.86%) and predatory fauna comprising of Coccinellids, spiders and ants were noticed active in the field at different stages of the crop.

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

Eumicrosoma spp. (Hymenoptera : Scelionidae) is a potential egg parasitoid of black bugs of sugarcane, *Cavelerious sweeti* Myamoto and *Dimorphopterus gibbus* and other Hemipteran insect pests of grasses. *Eumicrosoma* spp. is mass multiplied on laboratory reared black bugs of sugarcane. Black bugs were mass multiplied on natural host plants in the laboratory and *Eumicrosoma* spp. was mass multiplied on eggs of black bug through the method developed by Dr. Maha Ram Singh at ICAR-IISR, Lucknow in 2007.

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

Rearing of black bug completed in two steps.

Muslin bag for oviposition: A muslin cloth bag measuring 20.0 x 8.0 cm was taken. Three to four cut tops of sugarcane with 5 cm leaf portion are kept in a muslin bag and field collected male and female (1:1) are released in the bag. In one bag, 50 pairs of insect can be accommodated. After release of insects, open end of bag is closed with rubber bands and kept in a tray for egg laying. Eggs are glued to the bottom of tray which are collected daily and stored in homoeopathic vials at ambient room temperature for further development. Fresh eggs are rice shaped and creamy white in colour. At maturity, eggs become dark orange in colour.

Paper cone for nymph development: Paper cone was developed from a sterilized paper of 25 cm^2 size and cut cane (8-10) with leaf sheath. One such cut piece of sugarcane stalk was placed at the lower left corner of the paper and rolled in a manner that it takes the shape of cone without touching the upper end of cut stalk. Narrow end of the paper cone was tightened with the help of rubber bands. Mature egg (orange in colour) or freshly hatched nymphs are released in the paper cone and its upper broader end is closed by folding twice and inserting the rear corner of the second fold into the first one. Dried out setts and leaf tops were changed in 4-5 days in summer and 5-6 days interval in winter and rainy seasons.

Incubation, nymphal and total period of lifecycle varied from 7 to 10, 24 to 36, 31 to 60 days, respectively (Table 3.1).

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

Eumicrosoma sp. is a potential egg parasitoid of black bug of sugarcane. Biology and rearing of *Eumicrosoma* sp. was developed at ICAR-IISR, Lucknow. Nucleus culture of the parasitoid was maintained in the laboratory. *Eumicrosoma* sp. is a black shiny Sceilionid wasp. Eggs of black bug *D. gibbus* were used as laboratory host.

Fresh eggs (fresh or 24 hour old) are offered to the gravid female in homoeopathic vials for parasitization. Parasitized eggs became blackish in colour from one end and in few days turned completely black to shiny black just before hatching. No superparasitism was observed. Parasitization ranged from 38 to 80%. On an average, a female parasitized 15.67 eggs with a range of 5-22 eggs. Development period of parasitoid varied from 7-11 days. Parsitisation and longevity of adults varied from 62.5 to 91.50% and 1-3 days, respectively.

Table 3.1. Duration of different life stages of *Dimorphopterus gibbus*

Duration	Incubation period (days)	Nymphal period (days)	Total period (days)
February-March	7-8	25-27	32-35
April-May	8-9	25-27	33-36
June -July	7-8	25-29	32-37
August- September	7-8	24-28	31-36
October -November	8-9	27-30	35-39
December-January	9-10	45-50	54-60

CHAPTER 4

Research in Plant Physiology and Biochemistry

Impact of *Ethrel* and GA_3 to improve the survival of plants under drought

An experiment was conducted in autumn season using variety CoLk 94184 with four types of irrigation treatments i.e. M_1S_1 (100 % crop water requirement and 40% depletion), M_1S_2 (100% crop water requirement and 70% depletion), M_2S_1 (75% crop water requirement and 40% depletion) and M_2S_2 (75% crop water requirement and 70% depletion) were applied in seven treatments of plant growth regulators (T_1= control, T_2= control + water (spray), T_3= control + GA_3(spray), T_4= Water (overnight dipping of setts before planting), T_5= Water (overnight dipping of setts before planting) + GA_3 (spray), T_6= 100 ppm *Ethrel* (overnight dipping of setts before planting) and T_7= 100 ppm *Ethrel* (overnight dipping of setts before planting) + GA_3 in three replications. Results obtained indicated that NMC and yield was decreased by 7% and 17%, respectively in M_2S_2 (75% crop water requirement and 70% depletion) compared with M_1S_1 (100% crop water requirement and 40% depletion) after dipping in *Ethrel* + GA_3 spray.

Impact of NAA, *Ethrel* and GA_3 on sugarcane

Germination of buds in variety Co 0238, CoLk 09204, CoLk 94184 and CoLk 09202 was 29, 19, 30 and 18%, respectively after priming of setts in 100 ppm Naphthelene acetic acid (NAA) whereas in control, germination% was 18, 17, 26 and 8%, respectively in four varieties. With *Ethrel* (100 ppm) priming, germination % was 20, 13, 4 and 19%, respectively in varieties Co 0238, CoLk 09204, CoLk 94184 and CoLk 09202. The priming setts with 100 ppm NAA improved germination% more than *Ethrel* at same concentration at 45 DAP. Maximum increase in germination % was in variety Co 0238 and minimum was in variety CoLk 94184 with NAA (100 ppm). The reason for increased germination in Co 0238 with NAA was 15% increase in acid invertase activity and 12% increase in reducing sugar in germinating buds as compared with CoLk 94184. The proliferation of root was more with NAA treatment in variety Co 0238 as compared with CoLk 94184. Root dry biomass was 3.5 times higher in Co 0238 than CoLk 94184.

Impact of PGRs (NAA, BAP, *Ethrel*) on bud germination

An experiment was conducted on effect of PGRs (NAA, BAP, *Ethrel*) in autumn and spring season using variety CoLk 94184. Results obtained indicated increase in germination percentage with PGRs treatment. The highest increase was obtained in *Ethrel* treatment; 42% in autumn and 60% in spring planting (Fig. 4.1).

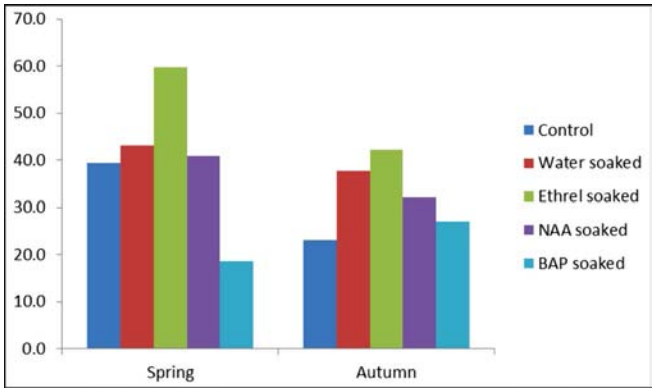

Fig. 4.1. Impact of PGRs on bud germination

Molecular study to reveal transcriptomes and genes associated with sucrose transport and accumulation in sugarcane

Two plant growth regulators namely *Ethrel* and gibberellin (GA_3) were contemplated to study their impact on physiological efficiency and source-sink dynamics using both early and late maturing varieties of sugarcane. Priming of cane seed (setts) with 100 ppm *Ethrel* not only improved the germination but also hastened it by 15-20 days. Gibberellin (GA_3) promoted rapid elongation and division of cells and thus showed impact on content of both hexoses and sucrose in source and sink tissues. It induced ~42.3% enlargement in cell size and about 39.3% increase in internodal length (sink capacity), 177% escalation in reducing sugar level (sink strength), amplified expression of sucrose metabolizing enzymes (sink demand) viz. 7.5 fold SAI, 4.5 fold CWI and 6 fold SPS. All these augmented more sucrose accumulation in the stalk. The GA_3 treated cane of BO 91 exhibited elevated final sucrose concentration (40.54%-41.6%) as compared to control (30.44%-38.8%). The GA_3 primed cane of early maturing CoJ 64 also showed such a boost, but did not sustain at maturity, perhaps due to inversion and/or less effective GA_3 treatment.

Profiling with respect to enzyme activity, reducing sugar, sucrose % was done in different portions of canes to visualize the impact of GA_3 on source-sink dynamics. A significant positive correlation was found between sucrose% of source and sink tissues.

It was found greater in the top internode (R^2=0.679) than middle (R^2= 0.580) and bottom (R^2= 0.518) internodes depicting that sucrose content in stalk depends on the source efficiency to synthesize it. High invertase activity as observed in top portion of cane lead to high reducing sugar (R^2 = 0.954) (Fig. 4.2). At immature stage, elevated expression of invertase was observed and its decline with maturity resulted in increased sink requirement. Higher sink demand resulted in enhanced photosynthetic rate as depicted with increased expression of PEP carboxylase gene. SPS was found active in the initial stage of cane development that demonstrated its function in sucrose synthesis.

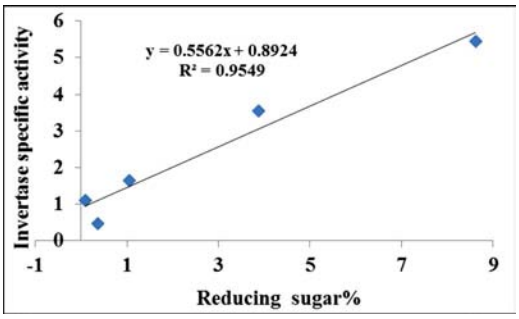

Fig. 4.2. Relationship between invertase activity and reducing sugar in top portion of cane

In transcriptomic study, the fold change as observed indicated that the starch and sucrose metabolizing genes showed maximum fold change of 5.0 and 3.0 among top and bottom internodal samples (Fig. 4.3). A homology match using Blastx analysis tool yielded 65 transcripts which were found to share homology with C_4 plants like *Saccharum*, Sorghum and Maize. Study also enriched sugarcane transcriptome resources useful for omics study in genus *Saccharum*. More than 75 primers-pairs have been constructed based on the sequences of novel and significant transcripts having significant fold change in top and bottom internodal tissues as well as GA_3 treated and untreated samples. These primers are being validated using real-time PCR.

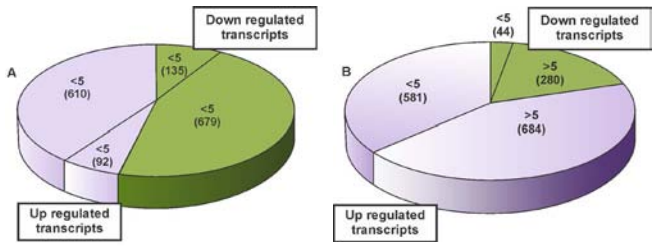

Fig. 4.3. Number of up regulated and down regulated transcripts in bottom region of control (SCB-1) and GA_3 treated (SGB-3) canes (A), and in top region of control (SCT-2) and GA_3 treated (SGT-4) canes (B) depending on the fold change

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

Four promising varieties of sugarcane namely CoLk 94184, CoLk 09204, CoPK 05191 and Co 0238 were used and juice analysis was performed at different period taking samples from control and Benzal konium chloride + sodium metasilicate (BKC + SMS) treated canes. Data were recorded at zero, 4 and 7 days of post-harvest treatment. At zero day, ^{0}Brix ranged from 18.61 to 22.12 and sucrose % juice from 16.76 to 19.84 among these varieties. After 4 days of post-harvest, an increase in Brix (21.54 to 24.64) and decrease in sucrose % juice (13.2 to 18.40) in control was observed. In SMS+BKC treated canes, these were 21.84 to 24.71 and 16.57 to 20.26, respectively. After 7 days of post-harvest, ^{0}Brix values increased further (22.73 to 27.1), whereas sucrose % juice decreased (12.64 to 19.81) in control, whereas in treated canes, these ranged from 22.78 to 26.3 and 15.63 to 20.13, respectively. Among these varieties, post-harvest deterioration (after 7 days of cane harvest) in terms of sucrose % juice was observed maximum in CoLk 09204, a decrease of 16.76 to 12.64 in control and 16.76 to 15.63 in SMS+BKC treated canes. Nevertheless, treated samples showed 3% less deterioration. Minimum deterioration was observed in CoPK 05191. Deterioration in cane quality due to delayed crushing of harvested cane found more pronounced due to high ambient temperature.

Screening and identification of sugarcane genotypes tolerant to waterlogging and their physio-biochemical investigation

Twenty three sugarcane genotypes including six commercial varieties (tolerant/susceptible) viz., CoLk 94184, BO 91, CoS 767, CoJ 64, CoS 97264 and UP 9530 and seventeen genotypes (CoLk 12204, CoLk 12202, CoLk 12206, CoLk 07201, CoLk 04238, LG 06605, LG 04439, LG 05350, LG 05020, LG 03040, A-46-11, B-44-12, A-27-12, D-12-9, D-6-13, S 5085/11 and S 5087/11) were evaluated for rooting pattern and root anatomy under waterlogged condition along with untreated control at Kharika Block, ICAR-IISR, Lucknow. Results obtained indicated reduced shoot dry mass due to waterlogging in all the genotypes except in CoLk 94184, CoLk 12204, CoLk 12206, LG 06605, LG 04439, D-6-13 and S 5085/11. In contrast, root dry mass (sum of shoot root and aerial roots) was relatively higher in waterlogged affected plants. Aerial rooting pattern varied among genotypes. Some of the genotypes showed aerial roots up to 12th nodes. UP 9530, CoS 97264, LG 04439, LG 05020, D-6-13, S5985/11 and S 5087/11 showed dense aerial root growth. Anatomical studies of roots using light

microscope indicated cortical cell distortion and loss of uniformity in endodermis and pericycle due to waterlogging. The size of metaxylem vessel showed reduction when compared with control roots. Waterlogged affected shoot roots exhibited higher number of metaxylem vessel as compared to aerial roots. Correlation analysis indicated positive association of root dry mass and number of metaxylem vessel with stalk dry weight under waterlogged condition. Based on these findings on root attributes, UP 9530, CoS 97264, LG 04439, LG 05020, D-6-13, S5085/11 and S 5087/11 may be grouped as tolerant genotypes.

Root anatomy of CoLk 94184 and CoJ 64 was investigated through SEM (Fig. 4.4 and 4.5). The SEM studies depicted morphological alterations and surface ultra-structural changes. Both shoot roots and aerial roots showed aerenchyma in cortical region but the size was relatively more in waterlogged roots. Compared to intact and uniform surface cells in control, irregular and damaged surface cells were observed in waterlogging. Waterlogging affected roots exhibited signs of injury in the form of cell distortion, and loss of uniformity in endodermis and pericycle regions. Level of deformation was relatively more in CoJ 64, indicating higher sensitivity towards waterlogging as compared to CoLk 94184.

Cane stalk under waterlogged condition were evaluated for juice quality attributes from the month of November 2017 to February 2018. On an average, pH, Sucrose%, CCS%, Brix and S/R ratio showed gradual increase from November to February. EC of juice and juice purity showed gradual increase from November 2017 to January 2018 and these showed slight reduction in the month of February 2018 (Table 4.1).

Na, K, Ca contents of leaf tissues were estimated. Na ranged from 0.126-1.275%, K ranged from 0.375-2.363% and Ca ranged from 0.176-0.508% (Table 4.2).

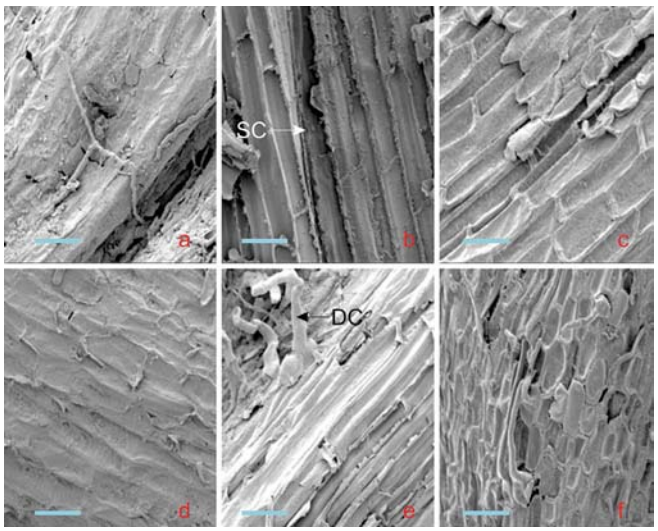

Fig. 4.4. Scanning electron micrographs (×500) of the root surface of sugarcane showing the effect of waterlogging a. CoLk 94184 (control); b. CoLk 94184 (waterlogged shoot root); c. CoLk 94184 (waterlogged aerial root); d. CoJ 64 (control); e. CoJ 64 (waterlogged shoot root); f. CoJ 64 (waterlogged aerial root); Bar - 100µm. SC, scrapped off cell; DC, damaged cells.

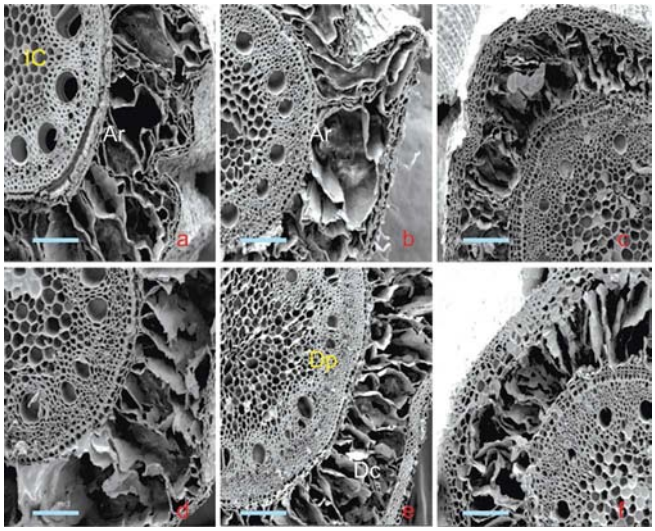

Fig. 4.5. Scanning electron micrographs (×170) of root cross section of sugarcane showing the effect of waterlogging on aerenchyma and pith region. a. CoLk 94184 (control); b. CoLk 94184 (waterlogged shoot root); c. CoLk 94184 (waterlogged aerial root); d. CoJ 64 (control); e. CoJ 64 (waterlogged shoot root); f. CoJ 64 (waterlogged aerial root); Bar - 300µm Ar, aerenchyma; IC, intact cell; DC, damaged cell; Dp, depositions.

Table 4.1. Juice analysis of waterlogging affected sugarcane genotypes

Parameter	November	December	January	February
EC	3.29-5.86 (4.81)	2.86-6.11 (4.82)	3.46-7.20 (4.90)	2.60-6.26 (4.76)
pH	5.18-5.42 (5.31)	5.15-5.51 (5.37)	5.20-5.57 (5.37)	5.35-5.81 (5.62)
Sucrose%	12.80-17.40 (14.64)	12.53-17.85 (15.98)	14.43-17.88 (16.33)	14.33-20.24 (18.22)
CCS%	8.64-11.95 (10.00)	8.60-12.39 (11.06)	9.89-12.37 (11.34)	9.72-14.06 (12.65)
Brix	15.19-19.95 (17.02)	14.42-20.03 (18.03)	16.61-20.23 (18.33)	16.87-22.70 (20.44)
Purity	81.56-87.25 (85.92)	86.80-90.38 (88.58)	86.38-90.75 (89.14)	84.89-90.02 (89.07)
S/R Ratio	26.6-40.06 (32.07)	28.88-90.33 (47.38)	33.83-105.82 (65.23)	41.03-185.50 (87.52)

Table 4.2. Nutrient analysis of waterlogging affected sugarcane genotypes

Parameter	Range	Mean
Na	0.126-1.275	0.269
K	0.375-2.363	1.543
Ca	0.176-0.508	0.310
Na/K	0.066-0.828	0.193
K/Na	1.21-15.11	8.085
K/Ca	1.04-9.92	5.185
Ca/K	0.101-0.963	0.235

Physiological and molecular bases of multiple abiotic stress tolerance in sugarcane

In order to identify tolerant traits specific to single/multiple abiotic stresses, a pot culture experiment was conducted using tolerant (CoS 767) and susceptible (CoJ 64) sugarcane varieties (Fig. 4.6a). Initially the seedlings were raised in plastic trays, thereafter grown in earthen pots under normal and saline soil (6 dSm^{-1}) conditions. The crop was imposed to individual stress of drought (at 75 DAP) and waterlogging (at 120 DAP for 60 days), and to their combinations. The different growth and physio-biochemical characters were recorded at the end of single/combined stresses. Leaf samples were collected, dried and grinded for analysis. The relative single cane weight of CoS 767 and CoJ

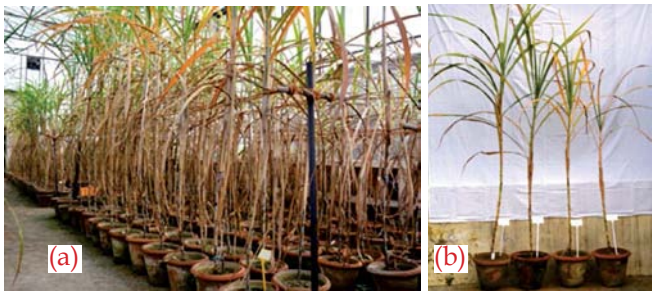

Fig. 4.6. (a) An overview of pot culture experiment: Multiple abiotic stresses (b) Effect of salinity, drought and drought + salinity on sugarcane variety CoJ 64

64 varied from 0.86 (waterlogging) to 0.56 (salinity + drought + waterlogging) and 0.84 (salinity) to 0.39 (salinity + drought + waterlogging), respectively (Fig. 4.6b). Significant variability existed between CoS 767 and CoJ 64 for stalk elongation rate, internodal length, leaf injury score, RWC, CSI, proline, fibre%, POX and CAT activity under single/combined stresses. The sucrose % reduced under all stresses and highest reduction was in combination of salinity + drought + waterlogging.

Externally funded project

Enhancing sugarcane bio-productivity: Physiological and molecular interventions using nutrient-hormone carriers (sponsored by CST, U.P.)

Present investigation was aimed to study the influence of soaking/foliar application of PGR and PGR + essential nutrients on germination, shoot population, growth, fresh weight of different plant parts, biochemical attributes, enzyme activity, yield and juice quality attributes of sugarcane. Treatments consisted of two sets; one, *Ethrel* soaked setts and control (unsoaked setts). Each set included seven treatments. Thus, the experiment comprised of a total of 14 treatment combinations; control (unsoaked setts) – T_1: No spray, T_2: *Ethrel* spray (100 ppm) at 75 DAP, T_3: T_2 + $ZnSO_4$ (0.5%) spray at 75 DAP, T_4: T_2 + GA_3 spray (50 ppm) at 130 DAP, T_5: T_3 + GA_3 (50 ppm) + $CaCl_2$ (1%) spray at 130 DAP, T_6: T_4 + Kinetin (100 ppm) spray at 175 DAP, T_7: T_5 + Kinetin (100 ppm) + $MnCl_2$ (0.1%) spray at 175 DAP, *Ethrel* soaked – T_8: No spray, T_9: *Ethrel* spray (100 ppm) at 75 DAP, T_{10}: T_9 + $ZnSO_4$ (0.5%) spray at 75 DAP, T_{11}: T_9 + GA_3 spray (50 ppm) at 130 DAP, T_{12}: T_{10} + GA_3 (50 ppm) + $CaCl_2$ (1%) spray at 130 DAP, T_{13}: T_{11} + Kinetin (100 ppm) spray at 175 DAP, T_{14}: T_12 + Kinetin (100 ppm) + $MnCl_2$ (0.1%) spray at 175 DAP. Results obtained indicated increase in germination due to *Ethrel* soaking, which was 155% and 55% over control at 35 and 55 DAP, respectively. Initial shoot population was higher in *Ethrel* soaking treatment (166/plot) than control (130/plot). Foliar application of *Ethrel* alone and in combination with nutrients at tillering phase increased tiller/clump; the highest (6.6) was obtained with *Ethrel* + nutrient spray. At elongation phase, foliar application of GA_3 alone and in combination with nutrient increased plant height, leaf area and shoot population; the highest (201 cm) was observed in *Ethrel* soaked with GA_3 + nutrient spray. Biochemical analysis indicated increase in chlorophyll a, b, carotenoids and NR activity due to foliar application of PGR and PGR + essential nutrients combination; the highest increase was obtained in T_{10}. The highest increase in SPS activity (92.08%) and the highest decrease in SAI activity (68.19%) was obtained in T_{14} treatment. Fresh and dry weight of different plant parts was increased in *Ethrel* treated setts; the highest increase in fresh weight and dry weight was obtained in T_{13}. Juice quality attributes gradually increased in all treatments periodically. The highest increase in sucrose % juice, CCS% and °Brix was observed in T_9 treatment, T_{14} was at par. Cane yield ranged from 83.31 to 106.76 t/ha; the highest cane yield 106.76 t/ha was obtained in control set with *Ethrel* + GA_3 + Kinetin spray (T_6) followed by setts with *Ethrel* + Nutrient spray (102.45 t/ha) (T_9) in plant crop. In ratoon crop, cane yield ranged from 100.45 to 127.40 t/ha; the highest cane yield was obtained in *Ethrel* treated sett (T_8) followed by *Ethrel* treated sett with *Ethrel* spray (126.44 t/ha) (T_9).

CHAPTER 5

Mechanization of Sugarcane Farming

Development of modified furrower type sugarcane cutter planter

Prototype of tractor operated sugarcane cutter planter with deep furrow opener was designed, developed and field evaluated. Attachments were also developed for mechanizing simultaneous sowing of intercrops like wheat, oilseeds and pulses with the sugarcane planting. Herbicide spraying attachments were also integrated with the planter for spraying of herbicides after putting the soil cover along with sugarcane planting. These attachments made the planter a multitasking machine saving more than 50% cost of operations and more than 90% human labour as compared to conventional method of sugarcane planting.

During the period under report, fertilizer dispensing system was redesigned and relocated for applying the fertilizer ahead of and 3-5 cm deeper than the setts. Newly developed prototype was field tested at IISR farm. Performance of the planter was satisfactory with effective field capacity of 0.20 ha/h. The developed prototype was also successfully field demonstrated at farmers field in Ballia and Shravasti districts of U.P. (Fig. 5.1).

Fig. 5.1. Field demonstration of newly developed planter at farmers' field.

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

Different attachments were developed for the designed tractor operated multipurpose tool frame. These attachments can be attached individually or in combination.

Furrow opening attachment

The field performance testing of the developed prototype was carried out at IISR farm for furrow opening mode (Fig 5.2). The furrow opening attachment *i.e.* deep furrowers (3 nos.) was attached with the tool frame and operated in the field having moisture content of 14.8% and bulk density 1.34 g/cm^3 at 2.0 km/h speed of operation. A trapezoidal deep furrow having top and bottom width of 32 cm and 18 cm, respectively was formed with depth of 25 cm and ridge height 15-16 cm. The field capacity of the equipment was 0.28 ha/h with field efficiency of 84%.

Fig. 5.2. Multipurpose tool frame with furrow opening attachments

Attachment for inter-row interculturing and intra-row herbicide spraying

The equipment was tested at IISR farm for interculturing and intra-row herbicide spraying in sugarcane (Fig. 5.3). The performance data of the

Fig. 5.3. Multipurpose tool frame with interculturing attachments

equipment has been furnished in Table 5.1. The interculturing attachment (six tines with shovel and three small full sweeps in between each pair of tines) and intra-row herbicide spraying attachment (flat fan nozzle, pump, battery and tank) was used with the tool frame. Equipment was operated 50 days after planting of sugarcane.

Table 5.1. Performance results of the machine

Parameter	Value
Height of the crop, mm	300-400
Speed of operation, km/h	2.8
Depth of interculturing, mm	90-110
Weeding efficiency, %	81.6
Inter-row tilled width, mm	450-500
Untilled width during interculturing, mm	250-300
Herbicide application rate, l/ha	270
Nozzle spray deposition width, mm	350
Effective field capacity, ha/h	0.54
Field efficiency, %	84.2

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

Two row disc type ratoon management device (Disc RMD) was developed for carrying out ratoon initiation operations in a ratoon field after harvest. Developed prototypes were of two types. First was without stubble shaver- to perform off barring and fertilizer application (Fig. 5.4). The second prototype has stubble shaver attachments also to perform stubble shaving along with off barring and fertilizer application (Fig. 5.5). Prototype without stubble shaver is suitable for piecemeal harvesting. Both types of prototypes were field tested at IISR farm. Disc RMD with stubble shaver attachment was also field tested at farmers' field (Hardoi).

Fig.5.5. Two row disc RMD with stubble shaving attachment

Development of cane node planter

Tractor operated cane node planter was developed (Fig. 5.6). It consisted of deep furrower, power transmission and cane node metering unit. These units were mounted on a sturdy mild steel framework. Performance of the planter was tested in the field. It planted two rows at a time. Cane node metering mechanism worked well and overall performance of the planter was satisfactory. Fertilizer dispensing system is needed to be developed and integrated with the planter.

Fig.5.4. Two row disc RMD without stubble shaver

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

AICRP on Farm Implements and Machinery (FIM)

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

Prototypes fabricated

S. No.	Name of the prototype	Quantity (Number)
1.	T.O. deep furrow sugarcane cutter planter	03
2.	T.O. sugarcane trench planter	03
3.	T.O. trench opener	05
4.	T.O. deep furrow opener	03
5.	T.O. deep furrow sugarcane cutter planter-cum-raised bed multi-crop seeder	01
6.	T.O. disc type ratoon management device	02
7.	Manual cane stripper	06
8.	Manual cane bud scooper/chipper	10
9.	Manual set cutting machine	05
	Total	**38** (T.O. -17, Manual- 21)

Prototypes supplied

S. No.	Name of the prototype	Quantity (No.)	Supplied to
1.	T.O. IISR Sugarcane Trench Planter	01	Tarapur, Ramsanehighat, Barabanki
2.	T.O. IISR Deep Furrow Sugarcane Cutter Planter with Herbicide Sprayer Attachment (Adjustable row spacing of 1.0, 1.2 & 1.5 m)	01	Agricultural Machinery Research Centre, AEC&RI, TNAU, Coimbatore
3.	T.O. IISR Disc Type Sugarcane Ratoon Management Device	01	Agricultural Machinery Research Centre, AEC&RI, TNAU, Coimbatore
4.	T.O. IISR Single bottom Trencher	02	College of Agriculture & Research Station, Gotiya Road, Kawardha, Dist.- Kabirdham - (01 No.) National Sugar Institute, Kanpur - (01 No.)
5.	IISR Manual Bud Scooper/Bud Chipper	03	Sh. S.P. Mishra, Gorakhpur- (01 No.) Mount Valley Development Association, Saharanpur - (01 No.) Sh. Shyam Karan Ojha, Faizabad - (01 No.)
6.	IISR Manual Sett Cutting Machine	03	Sh. S.P. Mishra, Gorakhpur - (01 No.) National Sugar Institute, Kanpur - (01 No.) Sh. Tauseef Khan, Faizabad - (01 No.)

2. Prototype Feasibility Testing (PFT)

Prototype feasibility testing (PFT) of Pant-ICAR sub-soiler cum differential rate fertilizer applicator

Prototype feasibility testing (PFT) of Pant-ICAR sub-soiler cum differential rate fertilizer applicator was conducted at IISR farm in one hectare area (Fig. 5.7). The performance of this equipment was compared with traditional planting system *i.e.* opening of furrows using ridgers, applying fertilizer, setts and soil covering manually. In the equipment under testing, the fertilizer was placed at differential depths whereas, in conventional system, setts and fertilizer are placed at same depth. The effective field capacity was 0.20

Fig. 5.7. Pant-ICAR sub-soiler cum differential rate fertilizer applicator in operation

ha/h at forward speed of 0.5 m/s. Higher germination percentage was recorded after 45 days of planting in case of the equipment than the conventional method.

Prototype feasibility testing (PFT) of tractor operated reaper binder

Feasibility testing of tractor operated reaper binder was conducted at farmers' field in different villages of Lakhimpur Kheri district of Uttar Pradesh for harvesting of wheat crop in more than 15 ha area (Fig. 5.8). Machine performs harvesting and binding of wheat in a single operation. The field capacity of the machine was 0.28 ha/h at 3.0 km/h forward speed. The height of cut was 8-12 cm above ground. Two labours (one tractor driver + one helper) were used during the operation. There was saving of 92% in labour requirement and 18% in cost of operations with this machine as compared to conventional practice of manual harvesting.

Fig. 5.8. Tractor operated reaper binder in field operation for wheat harvesting

UPCAR project "Centre of excellence in farm machinery"

Development of manual seed drill/planter

A single row manual seed drill/ multicrop planter was designed and developed for sowing intercrops in sugarcane. PVC rotor with vertical grooves on periphery was used for metering the seed. There is a provision to change the rotors as per the crops to be sown. The machine was having overall weight 15 kg, length 850 mm, width 170 mm and height 1040 mm. The drive to the seed metering shaft was from ground wheel through chain and sprocket. Two persons are required to operate the machine. Preliminary testing of the machine was carried out for sowing of Blackgram and Ladies finger. The capacity of the machine was 0.052 ha/h.

Development of sugarcane stripper cum detopper

For cleaning/detrashing of sugarcane after harvest manually, two models of sugarcane stripper cum detopper was designed, developed and tested (Fig. 5.9).

Model I **Model II**

Fig. 5.9. Developed sugarcane stripper cum de-topper

CHAPTER 6

Diversification and Value- addition in Sugarcane

Development of a jaggery furnace with efficiency boosting device

The miniature model of efficiency boosting device with nipples of 20 mm length and 4 mm diameter was tested and compared with device having plain holes of 4 mm diameter. The unit performed better but blockage of holes due to welding leading to improper exit of air was observed. This requires further correction.

Refinement of sugarcane cleaner cum washer for jaggery

The unit consists of two feed rollers having rubber flaps for gripping and pushing cane and four scrubbing rollers having wire brush for cleaning (Fig. 6.1). The rpm of first set of scrubbing rollers was kept three and a half times to the speed of feed rollers for better performance. For this, sprockets with 16 and 54 teeth on feed roller shaft and scrapping roller shaft, respectively were provided. Second set of scrapping rollers have not been given any drive so that it give resistance to canes and help in further cleaning of sugarcane. The unit was tested with a capacity of 210 kg/h cane. The results were compared with manual cleaning of cane and it was found that the unit is capable of doing medium level cleaning.

Fig. 6.1. Sugarcane cleaner-cum-washer (a) Cleaning unit, (b) Cleaned canes

Development of integrated drying system for jaggery drying

Design of main component of jaggery dryer for 50 kg drying capacity has been done with the required assumptions. These component are of drying chamber, arrangement of inlet and exit air. The designed dryer will offer 40^0 -50^0 C temperature.

AICRP on Post Harvest Engineering Technology (PHET)

Development of a semi-automatic jaggery manufacturing plant

A wet and dry vacuum cleaner was used together with strainer for scum removal from the pan during juice clarification. Two types of hoods were also tried. A molten jaggery pumping unit was designed and developed based on principle of vacuum suction (Fig. 6.2). It was tested for pumping of molten jaggery from the pan and the mechanism worked well.

Fig. 6.2. Molten jaggery pumping device

Development of sugarcane juice extractor for household use

Pushers were developed for both of centrifugal juicers so that sugarcane stalk could be pushed on the grinding plate. It was noted that rind of sugarcane was posing problems. Trials were done by removing the rind with the help of sugarcane peeler. With the peeled sugarcane stalk, the juicer was able to extract 40% of sugarcane juice. The capacity of the juicer was 350 ml per minute. Chocking was the main problem and it was overcome by cutting the sugarcane into small pieces leaving nodes. The feeding chute was also suitably blocked to prevent choking.

Study on determining storage losses in food grains in FCI and CWC warehouses and to recommend norms for storage losses in efficient warehouse

FCI as well as CWC godowns at Raebareli, Basti and Dhamora were visited and data and samples were collected as per guidelines issued by the Project Coordinator (PHET). All the stacks in Basti, Dhamora and Raebareli were liquidated. Loss and gain percentage is given in Table 6.1 . The data were verified at PC unit, Ludhiana. The data of CWC, Basti has been sent to PC unit. Data entry of Raebareli and Dhamora is in progress.

Table 6.1. Loss or gain percentage in rice and wheat at different warehouses

Werehouse location	Commodity	Stacking month	Loss/gain (%) after months					
			3	6	9	12	15	18
FSD, Dhamora	Wheat	June 2014	+0.09	+0.02	+0.36	+0.03	+0.21	+0.10
	Rice	June 2014	-0.82	-0.66	-0.41	-0.80	-0.94	-1.14
	Wheat (CAP)	June 2014	0.0	+0.29	+0.27	+0.01	---	
CWC, Basti	Wheat	June 2014	+0.49	+0.79	+0.59	+0.53	+0.44	+0.53
	Rice	June 2014	-0.97	-0.43	-1.03	-1.11	-1.23	-1.92

CHAPTER 7

Developing Sugarbeet Varieties Suitable for Indian Agro-climates

Evaluation of twelve varieties, including two checks (LS 6 and IISR Comp 1) revealed that SYT/06/25 and SR 96 maintained their superiority for sucrose content against LS 6 whereas none of the varieties surpassed IISR Comp 1, however, SYT/06/25 was close to it. Beet width was the highest in L 33. Brix was the highest in SYT/06/25 followed by SR 96 in comparison to LS 6 while none surpassed IISR Comp 1. Root weight was the highest in L 33 in comparision to the controls. Similarly, SYT/06/25 showed superiority in most of the traits except root weight and beet width.

Maintenance of sugarbeet germplasm

One hundred twenty two germplasm lines are being maintained; 65 new germplasm were grown at Mukteshwar for seed production during the year 2017-18.

Quality assessment of sugarbeet harvested in different months

Assessment of quality of sugarbeet harvested in different months were carried out in twelve sugarbeet germplasm.

In April harvest, beet weight was maximum in L 33 (7.4 kg); beet length was highest in LKC LB in comparison to LS 6, while none of the germplasm could out perform IISR Comp 1. Beet width was maximum in L 33 (12 cm). Brix was maximum in SYT/06/25 (17.6 cm) followed by SR 96 (17.2 cm) in comparison to LS 6 while none surpassed IISR Comp 1. None of the germplasm showed superiority against IISR Comp 1 in sucrose per cent. SYT/06/25 (12.32%) showed superiority in sucrose per cent against LS 6 (11.4%).

In May harvest, beet weight was maximum in Rasoul (4.86 kg) followed by LKC 2007 (4.08 kg) and LKS 10 (4.04 kg) in comparison to control. In sucrose per cent, R 06 (15.62%) was superior and was followed by LKC 2000 (15.56%). Brix was also superior in R 06 (20.7%), LKC LB (19.4%), LKC 2006 (19.0%), Shubhra (19.0%) than the controls.

In June harvest, amongst 12 germplasm, Shubra showed the highest Brix (22.12%). Second position was maintained by LKC 2000 (18.40%) in sucrose. In length and width of the beet, although length was recorded the highest in Rasoul (36.4 cm) and width in LKS 10 (14.6 cm). LKS 10 maintained its overall superiority by possessing 35.4 cm length, 14.6 cm width and weight (1.25 kg).

Post-harvest quality assessment of sugarbeet

Evaluation of post-harvest quality of sugarbeet was also performed. LKC LB performed better in sucrose per cent, commercial sugar and titrable acidity index, while LKC 2000 showed better performance in reducing sugars. In dextran content, LKC HB performed better in comparison to the control variety IISR Comp-1 after 6 h of harvest. Using LS 6 as control, LKC LB showed better performance in sucrose per cent and CBS (%) while in dextran, it was LKC HB after 6 h of harvest.

CHAPTER 8

Economics, Statistics and ICT

Impact of IISR technologies in sustaining sugarcane production

For impact analysis of Institute developed sugarcane cutter planters, the extent of its use by sugarcane growers has been estimated for different States and for different categories of farmers. Approximately 2.62 lakh cane growers are using sugarcane cutter planters in India. The labour saving has been estimated at 25 man days per ha. With the average cane farm size of 0.69 ha, this aggregates to a saving worth 45.20 lakh man days at national level. The monetary contribution of the machine due to labour saving was estimated to be more than ₹ 150 crores per annum. In order to assess the impact of sugarcane cutter planter on the economy of farmer and at the overall village economy, primary information from 20 users of the sugarcane cutter planters from western U.P. was also compiled and analysed.

For assessing the impact of intercropping in sugarcane, the information on the extent and nature of intercropping in sugarcane in Punjab was obtained by carrying out the survey involving 80 farmers. The compiled information revealed that adoption of large scale intercropping of sugarbeet, wheat and cauliflower to the extent of 1.5, 2.8 and 0.4 acre, respectively per farmer.

For assessing the impact of bio-control technology, the information on economic parameters pertaining to the bio-control of woolly aphid in sugarcane was compiled. The pest assumed the status of economic importance from 2001-02 when it infested large areas of sugarcane (Maharashtra and Karnataka) and caused considerable loss to cane tonnage (25%) and sucrose content (26.71%) under severe infestation. Similarly, the information for assessing the impact of bio-control technology for the management and control of top borer has also been assessed.

Institute made a pioneering effort in the development of phased multiplication of disease free seed cane using three-tier seed programme. The 3-tiers being the production of breeder seed, foundation seed and the certified seed cane in succession. Impact assessment parameters pertaining to this programme were compiled. The programme hovers around the MHAT of the seedcane for the production of breeders seed. The machine has the capacity of treating 4-4.5 quintals of seed cane per batch.

The variety CoLk 94184 developed by the Institute has gained popularity in vast areas of U.P., Bihar, Orissa and Chhatisgarh. After its release in 2008 and entering into the seed chain by 2011, the gradual increase in the area under this variety in U.P., has reached to the extent of around 6.27% of the total cane area. The area under CoLk 94184 in Uttar Pradesh which was 14014 ha during 2014-15 has increased to 1,44,198 ha during year 2017-18. The variety is good for adverse conditions of drought and water-logging wherein other varieties do not perform well. The variety ensures higher yield and more recovery in the risk prone areas.

Factors contributing economic viability of sugar and energy production complexes

The information was collected from 29 sugar mills from western, central, eastern U.P. and Uttarakhand during sugar season 2015-16, 2016-17 and 2017-18. The selected sugar mills were classified as standalone or integrated complex owned by cooperative or private corporate mills. Simple tabular analysis and appropriate statistical methods were applied to estimate cost, return and net profit. During sugar crushing season 2017-18, eight sugar mills from different regions of U.P and three sugar mills from Uttarakhand were surveyed.

Socio-economic factors contributing financial viability of sugar sector

Indian sugar industry provides livelihood to around 7.5 million sugarcane growers and 1.0 million skilled and semi-skilled workers employed in sugar mills and allied sectors. Sugarcane faced challenges due to climate change, water scarcity, higher input cost and labour wage escalation and ultimately decline in net profit to the farmers. In spite of these production constraints, sugarcane productivity has increased from 59.6 to 72.7 t/ha and sugar recovery has also improved from 9.20% to 10.86% during the period from 2012-13 to 2017-18 in U.P.

The wider adoption of CVRC released high sugar varieties, water saving irrigation techniques, mechanization in sugarcane planting, ratoon management, increase in autumn planting, intercropping with short duration crops and trench method of planting has improved cane productivity and net profit to the farmers. The area under early maturing variety (EMV) has increased from 9.26 to 70.3% during last five years. Major production constraints acknowledged by the respondents during survey were sugarcane monocropping with wheat,

non replacement of old and rejected cane varieties, low soil organic carbon, non-availability of quality seed of new varieties, late planting after wheat harvest, indiscriminate chemicals and fertilizer use, narrow row spacing, crop planting with three bud setts, and imbalanced use of plant nutrients. Farmers apply nitrogenous fertilizer (urea) in excessive quantity and less use of phosphate/potash fertilizer due to price disparity. They hardly apply FYM/bio-fertilizers and do not grow green manuring crop. The labour wages and cost of mechanical power have shown upward trends due to implementation of government schemes such as MGNERGA, petroleum products and fertilizers price escalation. Farmers have adopted sugarcane mechanization for planting and intercultural operations to address issues of labour scarcity and cost reduction.

Farmers realized better sugarcane productivity and reaped higher returns with adoption of EMV's such as Co 0238, Co Lk 94184, Co 0118, etc. and intercropping with pulses, oilseeds and vegetables in autumn planted cane, trench planting, wider row spacing, single/two bud setts in place of three bud setts, irrigation in trench to save water. Farmers adopted sugarcane cutter planter/ trencher for sugarcane planting, small tractor or multi-purpose power tillers for intercultural operations to minimize labour cost. The farmers cultivate pulses (chickpea, lentil, cowpea, pea etc.), oilseeds (rapeseed and mustard, linseed) and vegetables (potato, cabbage, cauliflower, onion, garlic) as intercrops in autumn planted cane for better utilization of wider row inter space (120-180 cm). They earned net income of ₹ 39,250 to ₹ 68,525/ha on the basis of intercrop sown and market price received. Farmers grow summer pulses or cucurbits as intercrops in spring planted cane to get additional income (₹ 32,500-41,000/ha). They utilize additional income from intercrops to purchase chemicals, fertilizers and labour wages payment.

Economics of sugar processing in U.P. and Uttarakhand

The cost of sugar and co-products processing includes raw material procurement as well as cost incurred by the sugar mills and various conversions cost of mills, overhead expenses for processing sugarcane into value added processed products. Table 8.1 revealed that the cost of sugar production in U.P. varied from ₹ 32,310 to ₹ 37,886 per tonne in a stand alone, integrated sugar-energy complex owned by cooperative or private sector. Ex-mill sugar price was ₹ 30,500 -33,500 per tonne during year 2017-18. The cost of sugarcane used as raw material has the lion's share and commanded more than 80% in total sugar processing cost. The average cane crushing capacity of surveyed sugar mills varied from 2,500 to 14,000 TCD in Uttar Pradesh and Uttarakhand. The integrated sugar- energy complexes used upgraded technologies and majority of cooperative owned sugar mills had

Table 8.1. Cost of sugar production during crushing season 2017-18 in U.P. (In ₹/tonne)

Particulars / Cost component	Standalone		Sugar + Cogen	Sugar+ Distillery+ Co-gen
	< 5,000 TCD		5,000-10,000 TCD	>10000 TCD
	Co op.	Private		
Sugarcane	31823	30019	28154	27232
Fuel and power	449	384	366	351
Chemicals	198	174	161	142
Manufacturing & processing	478	402	374	360
Repair & maintenance	385	327	282	168
Salary and wages	1026	1152	1018	937
Management & administration	542	468	374	285
Packaging material	414	406	396	390
Interest	573	479	522	547
Depreciation	267	338	253	173
Excise duty or GST @ 5%	1525	1450	1525	1550
Commission charges	79	76	72	71
Miscellaneous expenses	127	109	121	104
Total cost	37886	35784	33618	32310
Cane crushed (lakh.q.)	77.72	92.56	137.53	204.11
Sugar recovery (%)	10.19	10.82	11.54	11.92
Sugar production (lakh q.)	7.92	10.01	15.87	24.33
Crushing duration (days)	165	162	167	178

to increase crushing capacity and sugar recovery and make them economically viable, self sustainable and competitive with efficient private sector units in U.P.

Sugar recovery and co-products production varies considerably in sugar mills owned by cooperative or private sector. There are wide fluctuations in sugarcane supply to sugar mills which affects economic feasibility, profitability, cane price payment and ultimately outstanding cane price arrears. The subtropical sugar mills do not have comparative cost advantage as compared to tropical States. Hence, these sugar mills are in disadvantageous position and may hit harder due to transport cum freight costs for sugar exports. In addition, the Government of Maharashtra provides a monetary subsidy of ₹ 5000 per tonne for sugar export promotion.

Policy support for strengthening Indian sugar sector

The swelling sugarcane price arrears are the major concern as accumulated dues crossed ₹ 12000 crore on sugar mills for season 2017-18. Sugar production in the State has achieved a new record of 12.05 million tonne. As per ISMA estimate, sugar production of India may touch 32 mt during season 2017-18.

The Govt. of India has encouraged sugar export through reduction in export tax. The sugar export is yet to improve as prices in global market is low. The sugar mills demand for enhancing subsidy on sugar to the tune of ₹ 4500 per tonne for settlement of sugarcane price arrears. To improve economic viability of Indian sugar sector, the Govt. of India has also reduced GST on ethanol from 18 to 5% and encouraged diversion of B heavy molasses for ethanol production. The ethanol price was enhanced from ₹ 40.85 to 43.70 per litre. The price of ethanol produced from B-heavy molasses has been fixed at ₹ 47.49 per litre to encourage sugar mills to divert cane juice for ethanol production to bail out economic hardship.

The Government has made obligatory Minimum Indicative Export Quota (MIEQ) for sugar export promotion. However, Indian sugar mills demand more economic incentives to make sugar exports viable because of lower international prices. Bumper sugar production and demand-supply disequilibrium resulted in market glut. The Government permitted 2.0 m t sugar export under MIEQ scheme during sugar season 2017-18 to clear surplus sugar stocks and improve cash flow for cane price arrears payment. These policy measures may reverse domestic market sugar price trend. However, surplus sugar supply in domestic market could dent on sugar mills to export sugar at prevailing international prices, unless Government provides additional economic benefits and incentives on sugar export, as international sugar prices are now 25-30% less as compared to domestic prices.

Estimation of techno-economic feasibility of sugarbeet cultivation for sugar and ethanol production in India

The key features of sugarbeet cultivation, its socio-economic feasibility, institutional arrangements in marketing and the farm-factory relations were analyzed by carrying out a survey of 40 sugarbeet growers in Amritsar, Kapoorthala, Jalandhar and Batala districts of Punjab. Sugarbeet cultivation in Punjab was carried out under contract farming mode with a sugar mill (Rana Sugar Limited). The analysis of contract agreements between the sugarbeet growers and the sugar mill revealed that the agreement was on procurement and input supply under which the sugar mill agreed to purchase the produce of the contracted acreage at fixed price.

The mill also provided inputs like seed on credit (imported seeds from SES Vanderhave, a Belgium based company), technical advice and the sugarbeet harvesting machine on custom hiring basis. Around 75 per cent cost of seeds and 25 per cent cost of insecticides and pesticides to the growers was subsidized. The payment for input costs was deducted while making price payments after the harvest of the crop. As per agreement, the farmers are required not to irrigate the crop one week prior to harvesting in order to facilitate the operation of harvesting machine. An imported sugarbeet harvesting machine was provided to the growers by the sugar mill on contract hiring basis. Around 60% of the sugarbeet growers availed the machine.

As per agreement terms for cropping, the sugar mill have to pay the amount equal to the prevailing MSP of wheat crop for a yield of 50 q per ha, in case of sugarbeet crop failure. The binding for the farmer was to pay penalty equivalent to 10% of the value of the crop if he does not sell 85% of the produce to the sugar mill.

Sugarbeet growers are generally having higher holding size, the average size was 19.5 acres. All the operated area of the sugarbeet growers was well irrigated, about 79% were underground water irrigation and about 21% were under canal irrigation. About 70% of the sugarbeet growers had leased-in land. The extent of area under agreement for sugarbeet cultivation increased with the size of land holding. The extent of owned land put to sugar beet cultivation was also higher, to about 60%. The proportion of sugarcane

in GCA was (7.5%), wheat and rice was 25% and 41%, respectively. Analysis of comparative economics of wheat and sugarbeet revealed that though the total cost of sugarbeet cultivation (₹ 93,500 per ha) is almost double as compared to wheat (₹ 48,000 per ha), the net returns per hectare were almost the double compared to wheat. The requirement for labour was four times higher compared to just 16 man days required per ha for wheat crop. Around 60% of the total labour in sugarbeet was required for manual weeding operations. There is a high demand for more female workers in sugarbeet growing while there is marginal demand in wheat cultivation.

Socio-economic analysis of the sugarbeet growers revealed that these growers were educated and influential in social, political and administrative framework. The income from agricultural and allied non-farm activities per month were also 1.5 times higher compared to that of non-sugarbeet growers in the locality. The machinery ownership level was also good, around 95% were owning tractors. An analysis of the perceptions of the sugarbeet growers revealed that 80 per cent farmers realised that sugarbeet gave more returns as compared to wheat. About 60% farmers were convinced that sugarbeet improved land quality. Around 40% farmers were desirous to shift away from wheat. Fixed income, assured market and better price were the other reasons for getting involved in sugarbeet farming in Punjab. The shortage of labour and weed problem were the major constraints faced by the farmers.

Genetic improvement in sucrose (%) of sugarcane clones tested under AICRP(S)

Under new zonal varietal trial in sugarcane, elite clones are evaluated since 1998-99 in all five sugarcane agro-climatic zones (Table 8.2). An attempt has been made to assess the genetic improvement in sucrose (%) in elite clones of sugarcane evaluated in zonal varietal trials conducted.

The overall genetic improvement in sucrose was not found progressive as it was reported in cane yield in all the four zones during 1991 to 2015, i.e. 1.57% during 1991 to 2000, 2.01% during 2001 to 2010 and 0.37% during 2011 to 2015 over the period 1989-90 (Table 8.3). The highest genetic improvement 5.52% was observed in Peninsular Zone during period 2011 to 2015 followed by 5.41% in NW West Zone during 2001 to 2010 and 4.95% during 1991 to 2000 in Peninsular Zone over the base period. The sucrose % increased from 17.38 to 17.73 during 2001-2010 in all zones. The lowest genetic improvement (negative) was observed in East Coast Zone during the period 2001-2010 (-2.81%), followed by 2011-15 (-2.38%) and (-1.22%) during 2011-15 in NW Zone. The genetic improvement trend was positive in NC and NE Zones during (2001-2015). In recent years, the genetic improvement in sucrose % is positive in Peninsular

Table 8.2. Number of entries tested in Initial Varietal Trials (IVT) and Advance Varietal Trials (AVT) during 1989-2015

Zone	Early		Mid-late		Over all
	AVT	IVT	AVT	IVT	
Peninsular Zone	132	238	202	348	920 (39.81)
East Coast Zone	92	61	44	41	238 (10.30)
North West Zone	77	151	138	239	605 (26.18)
North Central Zone	100	95	111	153	459 (19.86)
North Eastern Zone	35	14	29	11	89 (3.85)
Total	436 (18.87)	559 (24.19)	524 (22.67)	792 (34.27	2311 (100)

Table 8.3. Genetic improvement in sucrose (%) of sugarcane clones under AICRP(S)

Year	Peninsular Zone	East Coast Zone	North West Zone	NC and NE Zone	Overall
1989-1990	17.43	17.26	17.38	17.23	17.38
1991-2000	18.30 (4.95)	17.59 (1.93)	17.58 (1.18)	17.12 (-0.60)	17.65 (1.57)
2001-2010	18.24 (4.65)	16.78 (-2.81)	18.32 (5.41)	17.57 (1.18)	17.73 (2.01)
2011-2015	18.39 (5.52)	16.85 (-2.38)	17.16 (-1.22)	17.36 (0.75)	17.44 (0.37)

Figure in parenthesis is per cent increase over average sucrose (%) of 1989 to 1990

Zone and NC & NE Zone where as in case of NW Zone and EC Zone was negative.

Development of data mining and presentation tools and web based reporting system for AICRP(S)

A new website of All India Coordinated Research Project on Sugarcane has been developed using HTML, Java, JavaScript, CSS, etc. More than 80 web pages were developed and added covering activities, structure, network, centres, projects, achievements, publications, impact, collaborations, awards, reports, messenger, contacts, sugarcane/sugar links, events, news, etc. Further, various reports viz. Coordinator's Report, PI Report, Centre's Annual Report, AICRP Technical Programme in the form of PDF file (400+) were uploaded and linked in the new website.

To start with the programme, website of AICRP(S) launched on the Institute Foundation day , 16th February, 2018 by Dr. R K Singh, Assistant Director General (CC), ICAR. Stakeholders can access AICRP website using URL http://www.iisr.nic.in/aicrp/index.htm.

AICRP(S) regularly conducts multi-location trials of breeding materials, production techniques, pest/disease management strategies, etc. Data generated out of these trials at 22 regular and 15 voluntary centres are reported to the Project Coordinator for further recommendations. Lack of common analysis and reporting platform at these centres poses the problem of interpretation of results and poor documentation.

A programme development is on the way to coordinate all the activities seamlessly and error free data reporting, analysis and interpretation.

CHAPTER 9

All India Coordinated Research Project on Sugarcane

AICRP on Sugarcane is providing research support for developing sugarcane technologies involving State Agricultural Universities, ICAR Institutes, State Govt. Departments and NGOs. The research programme pertaining to four disciplines viz., Crop Improvement, Crop Production, Plant Pathology and Entomology are implemented in five sugarcane growing zones in the country. There are 22 regular centres comprising 20 centres funded through AICRP on Sugarcane and 2 centres are ICAR Institutes. Besides, SAUs also participate voluntarily in implementation of technical programme of AICRP(S).

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

Mandate

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

Objectives

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

Research Achievements

Crop Improvement

Identification of sugarcane varieties

Three sugarcane varieties viz., CoLk 11206 (Ikshu-4) in mid-late group & CoLk 11203 (Ikshu-5) in early group from ICAR-IISR, Lucknow for North West Zone and CoA 11321 in early group from RARS, Anakapalle for East Coast Zone were identified for release.

Zonal Varietal Trial

A total of 30 Zonal Varietal Trials (16 in early and 14 in mid-late) were conducted. There were 8 IVT and 22 AVT trials. A total of 67 entries in early group and 91 entries in mid-late group were evaluated of which 16 in early and 22 in mid-late were promising.

Fluff Supply Programme

- National Hybridization Garden (NHG) was planted with 629 parental clones during 2016-17. Flowering was delayed by two weeks and out of 629 parents, only 330 flowered (52.46%) against 58.26% in the previous year.
- Nineteen centres participated in the crossing programme. The centres were facilitated to make 502 bi-parental crosses and 42 selfs at NHG at ICAR-SBI, Coimbatore. Besides bi-parental crosses, 12 poly crosses, 94 general collections of open pollinated fluff (GCs) were also made for these centres. Further, 12 centres were facilitated to effect 60 bi-parental crosses and 40 GCs at National Distant Hybridization Facility (NDHF) available at ICAR-SBIRC, Agali. Altogether 562 bi-parental crosses, 42 selfs, 12 poly crosses and 134 GCs were effected. Fluff weighing 19.52 kg obtained during 2016 flowering season was supplied to the 20 participating centres.

Crop Production

- Surface and sub-surface drip irrigation in sugarcane effectively saved water (up to 40%) and increased the crop productivity by 20%. Fertigation with drip resulted in 25% saving of nitrogen compared with surface irrigation. However, with the application of 100% RDN in drip irrigation cane productivity could be increased. Drip irrigation system once installed can effectively be used for 5 years (up to fourth ratoon).
- Application of 20 t FYM/ha compost along with inorganic fertilizers applied on the basis of soil test, soil test crop response for targeted yield or on the basis of general recommendation for the region has shown positive effect on sugarcane growth and yield both in plant and ratoon crops. Response of bio-fertilizers (*Azotobacter/Acetobacter/ Azospirillum/ PSB*) was more pronounced in peninsular zone. Use of organic sources of nutrients in plant-ratoon system brings about substantial enhancement of soil health parameters in most of the sugarcane growing soils.
- Efficacy of *Ethrel* on accelerating and enhancing germination in sugarcane has been reported from almost all the centres and 50 ppm *Ethrel* was found equally effective as 100 ppm. Spray of GA_3 (35 ppm) during tillering enhanced cane yield effectively across the zones, however, for North West Zone, sett soaking in *Ethrel* performed equally well and there was no additional yield increment with GA_3 spray during tillering phase.
- Use of mulch in sub-tropical zone and green manuring followed by mulching and residue incorporation resulted in higher net return.
- Zone wise the best performing early genotypes are: North Western Zone (CoH 11262, CoLk 11202, CoLk 11203, CoLk 11201); Peninsular Zone (Co 10006, Co 10004, Co 10005, Co 10024, Co 10027, CoT 10367, Co 10026); East Coast Zone (CoA 12322, CoV 12356, CoA 12321, CoOr 12346); North Central Zone (CoP 11436, CoSe 11451, CoP 11438) while in mid-late genotypes, North Western Zone (CoLk 11206, CoPb 11214, CoH 11263, CoS 11232, CoLk 11204); Peninsular Zone (CoT 10369, Co 10031, Co 10033, PI 10131, Co 10015, CoM 10083, PI 10132, Co 09009); North Central Zone (CoSe 11455, BO 155). In North Eastern Zone, both early and midlate genotypes performed similar and below the performance of check varieties.

Crop Protection

Plant Pathology

- Eleven projects were undertaken in the discipline of Plant Pathology in 21 centres.
- Several variants of red rot pathogen have been isolated from the popular varieties viz., Co 89003, CoJ 64, CoS 8436, CoSe 92423, CoSe 95422 and Co 0238. The possible emergence of two new pathotypes viz., R 1102 and R 1304 have been reported from Shahjahanpur centre.
- The new isolates RI 303 and RI 305 virulent as pathotype Cf 08 have been reported from Kapurthala centre. Karnal centre reported a new isolate Cf 89003 which exhibited more virulence with I to S reactions on 14 differentials, suggesting the possible emergence of new pathotype in the subtropics.
- Fifteen centres undertook red rot testing, 16 for smut and 6 have screened the clones for wilt resistance and identified numbers of entries as R/MR to red rot, smut and wilt from all the four zones.
- During standardization of methodology for inoculation of uredinospores of brown rust, leaf whorl inoculation was found best and it may be used for screening of sugarcane genotypes against brown rust.
- Management of brown spot disease of sugarcane by using Propiconazole 0.1% reported successful by Padegaon centre.

Entomology

- The genotypes/varieties CoS 8436, CoPb 10182, CoS 10231, CoS 10261, CoH 11263 and CoLk 12205 showed highly susceptible to root borer and top borer, respectively in North West Zone.
- The varieties CoSnk 130102, Co13004, Co 85004, MS 13081, Co 1001, CoM 11084, CoM 11082, Co 1004, Co 10026, Co 13006, Co 13008, Co 13009; MS 13081, CoSnk 13102, Co 1101, Co 1104, Co 11081, Co 10006, Co 10027, Co 13004, CoN 13071, CoN 13072, CoSnk 13101, CoSnk 13102, CoSnk 13106, PI 13132; Co 13002, Co 13003, Co 13004, CoN 13071, CoN 13072, CoSnk 13101, CoSnk 13102, CoM 11081, CoM 11082,CoM 10084, Co 10004, Co 10005, Co 10024, Co 10026, CoJ 10366 and Co 11001, Co 11004, CoM 11081, CoM 11082, CoM 11084, Co 10004, Co 10005, Co 10006, Co 10024, Co 10026, Co 10027, CoT 10366, CoT 10367 showed highly susceptible to scale insect, early shoot borer, internode borer, and mealy bug, respectively in Peninsular Zone.
- The high incidence of early shoot borer, root borer, internode borer, black bug, web mite, pyrilla, white fly, mealy bug and white grub were reported in different varieties in different zones.
- The egg parasitoid, *Trichogramma chilonis, Tetrastichus pyrillae;* larval parasitoid: *Isotima*

javensis, Rhaconotus scirpophagae, Stenobracon sp., *Sturmiopsis inferens, Cotesia flavipes*; nymphal and adult parasitoid, *Epiricania melanoleuca* and fungus, *Beauveria bassiana* were observed on insect-pests.

- The multiplication of parasitoids, *Eumicrosoma* sp., *Trichogramma chilonis, T. japonicum, Chrysoperla zastrowi sillemi, Epiricania melanoleuca* and fungus *Beauveria bassiana* was done on different host in the laboratory.

Technology developed

- Sub soiling/Chiseling for sugarcane planting has been developed and advocated for adoption.
- For the ease of mechanical harvesting, wider row spacing (120 cm or 120:30 cm) is recommended.

Group Meeting under AICRP on Sugarcane

The Group Meeting of All India Coordinated Research Project on Sugarcane was hosted by the Tamil Nadu Agricultural University, Coimbatore (Tamil Nadu) during September 22-23, 2017. The Opening Session was held under the Chairmanship of Dr. Bakshi Ram, Director, ICAR-SBI, Coimbatore. On this occasion, Dr. K. Ramasamy, Vice-Chancellor, TNAU, Coimbatore was the Chief Guest. Dr M. Maheswaran, Director of Research, TNAU, Coimbatore welcomed all the delegates and participants.

Recommendations (Plenary Session)

The plenary session was held on September 23, 2017. The Chairman invited Principal Investigators/ Rapporteurs for presentation of the proceedings of different technical sessions. The following recommendations were made:

- All the centers will adhere to the name as given by the AICRP(S) while releasing and commercializing the genotypes/varieties, developed and tested through AICRP(S).
- Using internet facility by the AICRP(S) centres for digitization of the data recording of AICRP(S) trials.
- A treatment on drought should be regular components in Crop Production trials of AICRP(S) and only newly released varieties should be used in the drought experiments.
- The quarantine protocol must be strictly followed while importing varieties to tackle the issue on spread of diseases effectively in the country.

Varietal Identification Committee Meeting

Varietal Identification Meetings were held under the Chairmanship of Dr. R.K. Singh, ADG (Commercial Crops), ICAR, New Delhi on September 23, 2017 at TNAU, Coimbatore during Group Meeting of AICRP(S). To discuss the earlier submitted proposals, again a meeting was called on November 22, 2018 at ICAR-Indian Institute of Sugarcane Research, Lucknow under Chairmanship of Dr A.K. Singh, DDG (CS & HS), ICAR, New Delhi. In the meetings, following three sugarcane clones were identified for release:

- First proposal submitted by ICAR-IISR, Lucknow in mid-late group for identification of CoLk 11206 (Ikshu-4) was discussed. Area of adoption for this variety is North West Zone. Sugarcane clone was found superior with respect to yield (91.80 t/ha) and CCS (11.28 t/ha) yields. The clone was tested with three checks of the zone i.e. CoPant 97222, CoS

767 and CoS 8436. Considering the superiority of this clone in cane yield, CCS (t/ha), sucrose % juice and pol % cane, it was identified for the release in North West Zone.

- Second proposal submitted by ICAR-IISR, Lucknow in early group for identification of CoLk 11203

(Ikshu-5) was discussed. Area of adoption for this variety is North West Zone. Sugarcane clone was found superior with respect to cane (81.97 t/ha) and CCS (10.52 t/ha) yields. The clone was tested against the two checks viz., CoJ 64 and Co 0238. This clone was superior in all the characteristics i.e. cane yield, CCS (t/ha), sucrose % juice and pol % cane and it was identified for the release in North West Zone.

- Third proposal submitted by RARS, Anakapalle in early group for identification of clone CoA 11321. Area of adoption for the variety is East Coast Zone. Sugarcane clone was found superior with respect to cane (111.31 t/ha), CCS (13.59 t/ha) yields, Sucrose (17.16%) in juice and Pol (13.73%) in cane. The clone was tested with two checks of the zone i.e. CoC 01061 and CoA 92081. The proposal was discussed in the meeting. This clone was found superior in all the characteristics i.e., cane yield, CCS (t/ha), Sucrose (%) in juice and Pol (%) in cane and it was identified for the release in East Coast Zone.

Purification of the seed of old varieties through tissue culture

Dr R.C. Pathak, Joint Cane Commissioner, State Cane Deptt, Uttar Pradesh discussed on severe incidence of GSD in the variety Co 0238 in few pockets of Uttar Pradesh. Committee opined that purification of the seed of old/existing varieties through tissue culture techniques is required. If a good sugarcane variety is declining due to seed borne diseases, the varietal purification programme may be taken up by the ICAR-IISR, Lucknow and other research institutes as well. Representatives of National Seed Corporation were also agreed upon to take up the programme for the benefit of farmers. After seed purification, multiplication programme of old varieties may be taken up by the progressive farmers/State Cane Deptt./State or ICAR Institutions.

Zonal Breeders Meet

Zonal Breeders' Meet - 2018 of AICRP on Sugarcane was organized at ICAR - Indian Institute of Sugarcane Research, Lucknow on January 19, 2018 to finalize the sugarcane genotypes for the Advanced Varietal Trials. Sugarcane breeders from various research institutes, universities, centres' working under All India Coordinated Research Project on Sugarcane and state cane development officials participated in the Meet. The meet was inaugurated by the Chief Guest, Sri Sanjay R. Bhoosreddy, Principal Secretary, Cane Development & Sugar Industries and Cane Commissioner, Govt. of Uttar Pradesh. At the outset, Dr. S.K. Shukla, Project Coordinator (Sugarcane) accorded warm welcome to all the delegates and initiated the proceedings of inaugural session by presenting results of Initial Varietal Trials.

The technical session of the Zonal Breeders Meet was chaired by Dr. Bakshi Ram, Director, ICAR-Sugarcane Breeding Institute, Coimbatore and Principal Investigator (Crop Improvement), AICRP(S). Selection of IVT entries for promoting to AVT, fluff supply programme and National Hybridization Garden were discussed in the meeting. Important decisions taken in the meeting are given below:

- In East Coast Zone, four entries were evaluated in IVT (E) and three entries viz., CoC 15336, CoC 15338 and CoV 15356 were selected based on juice sucrose % at 10th month, red rot resistance and field stand. These three entries will be evaluated in AVT (E) I Plant during the year 2018-19.
- Based on the juice quality traits, resistant to red rot and cane stand, out of five entries tested in IVT (ML), two entries namely, CoC 15339 and CoOr 15346 were selected. These entries will be multiplied for one year in all the centres during the year 2018-19 for testing in AVT (ML) I Plant during the year 2019-20.
- In North West Zone (NWZ), among the seven entries evaluated in IVT (E), four entries viz., Co 14034, CoLk 14201, CoPb 14181 and CoPb 14211 were selected based on juice sucrose % at 10th month, red rot resistance and field stand. These four entries will be evaluated in AVT (E) I Plant during the year 2018-19.
- Among the 13 entries tested in IVT (ML), seven entries namely, Co 14035, CoH 14261, CoLk 14203, CoLk 14204, CoPb 14184, CoPb 14185 and CoS 14233 were selected for conducting AVT (ML) I Plant during the year 2018-19.
- In North Central and North East Zones, eight entries were evaluated in IVT (E) and four entries

viz., CoLk 14206, CoP 14437, CoSe 14451 and CoSe 14454 were selected for testing in AVT I Plant (Early) during the year 2018-19.

- Nine entries were tested in IVT (ML) and five entries viz., CoLk 14208, CoLk 14209, CoP 14438, CoP 14439 and CoSe 14455 were selected for testing in AVT I Plant (Midlate) during the year 2018-19.
- Scientists should present the growth performance of entries in IVT in comparison to the best standard under three categories viz., Better, At Par and Poor for promoting the entries in IVT to AVT during Zonal Breeders Meet.
- Some of the breeders are attending crossing programme at the end of the crossing season when desired parents in flowering stage are less. The breeders should attend the crossing programme at appropriate time to make desired and targeted crosses effectively.
- In North West Zone, juice analysis must be done during 2nd fortnight of November, January and March for uniform results across the zone.
- All the centres must attend the Zonal Breeders Meet and present data for effective selection of entries for promoting from IVT to AVT. Full set of data must be sent in advance to the PI (Crop Improvement), AICRP(S) if the breeder is not able to attend the meeting due to unavoidable circumstances.
- Sucrose % in juice reported for many entries was unusually low in some centres. The field should not be irrigated atleast for 15 days before the samples are taken for the juice analysis. The newly joined scientist from Bethuadahari may get acquainted with the juice analysis procedure at ICAR-IISR, Lucknow.
- Highly susceptible reaction of Co 05011 to red rot was reported by Faridkot centre, while other centres reported MR/R reactions. Hence, the red rot reaction of the standard may be checked again by Faridkot centre.
- Red rot incidence on PI 16376 was reported by Nellikuppam centre. Hence, the entry may be removed from evaluation and need not be included in the IVT (ML) during the year 2018-19 in East Coast Zone.
- The seed multiplication centre, Karnal reported shortage of seed materials for the entry CoLk 15202. Hence, the entry will be multiplied again by Karnal centre along with entries of 2017 series.
- Shortage of seed materials were reported by some centres in North West and North Central Zones. The seed materials should be exchanged as per the details given below:

Entry	Seed supplying centre	Seed receiving centre
CoS 16231	Shahjahanpur	All centres of North West Zone except Karnal
CoSe 16454 CoSe 16455 CoSe 16456	Seorahi	Pusa. The Pusa centre will multiply these entries along with the entries of 2017 series
Co 15024	Karnal	Kota
CoS 15231	Karnal	Uchani
Co 15024 Co 15026	Karnal/Uchani	Muzaffarnagar
CoLk 15209	Lucknow	Shahjahanpur

- The Zonal Breeders Meet is organized for promoting the selected superior entries in IVT to AVT directly by skipping multiplication between these trials save one year in the varietal development and release process. It also provides opportunity for the sugarcane breeders from East Coast Zone, North West Zone and North Central and North East Zones to discuss on promotion of entries and other issues related to sugarcane breeding in respective zones.

CHAPTER 10

Outreach Programmes and Technology Management

Entrepreneurship development for sugarcane seed production and multiplication

Limited availability of healthy seed material is a major impediment in the replacement of old and rejected cane varieties with newly released varieties. Many factors are responsible for this undesirable situation; few important among them are poor mechanism of seed cane production and distribution, lack of entrepreneurial ability among farmers to venture out in seed cane production enterprise and lack of technical know-how in seed cane production and distribution among farmers. To address these problems, the project is being implemented with the following objectives:

- To promote entrepreneurial ability among sugarcane farmers
- To evolve mechanism for availability of healthy sugarcane seed material for planting
- To introduce appropriate technological interventions in sugarcane based production systems for enhancing farm income
- To implement outreach activities in PPP mode for enhancing farm yield and income of farmers.

During 2017-18, seed cane crop of eight selected varieties viz., CoLk 94184, CoLk 09204, Co 098014, CoPK 05191, Co 0118, Co 0238, CoS 8272, Co 05011 was planted on farmers' fields in Sitapur, Barabanki, Lakhimpur, Shravasti and Ballia districts of Uttar Pradesh. A total of 73 seed cane plots in 28.84 ha area was maintained in 18 villages. (Table 11.1). The average yield obtained for seed cane crop of different varieties raised during 2016-17 were 125, 125, 86, 104, 105, 89 and 140 t/ha for varieties CoPK 05191, Co 0118, CoH 128, CoLk 94184, CoLk 9709, Co 05011 and Co 0238, respectively. However the average seed cane yield for all varieties was 111.43 t/ha (Table 11.2). A total of 1696.90 tonne seed cane was produced out of which 56.61% was utilized as seed material and rest of the harvested cane was supplied by farmers to sugar

Table 11.1. No. of plots and area under seed cane crop of different sugarcane varieties (2017-18)

Variety	Number of plots	Area in ha
CoPK 05191	05	2.00
Co 0118	12	5.00
Co 0238	28	12.00
CoLk 94184	10	4.60
Co 05011	4	0.80
CoLk 09204	5	1.10
Co 098014	6	2.50
CoS 08272	3	0.80
Total area	**73**	**28.84**

Table 11.2. Yield, production, utilization and economics of seed cane crop (2016-17)

Variety	Average yield (t/ha)	Seed cane produced (t)	Utilization pattern (in t)		Return (₹/ha)			Net profit (₹/ha)
			Seed multiplication	Crushing	Seed	Crushing	Total	
CoPk 05191	125	437.50	52.5 (12%)	385.00 (88%)	60000	357500	417500	297500
Co 0118	125	375.00	300.00 (80%)	75.00 (20%)	400000	81250	481250	361250
CoH 128	86	17.20	0.00 (0%)	17.20 (100%)	0	270900	270900	150900
CoLk 94184	104	208.00	166.40 (80%)	41.60 (20%)	332800	67600	400400	280400
CoLk 9709	105	126.00	75.60 (60%)	50.40 (40%)	252000	136500	388500	268500
Co 05011	89	71.20	42.72 (60%)	28.48 (40%)	213600	112140	325740	205740
Co 0238	140	462.00	323.40 (70%)	138.60 (30%)	392000	136500	528500	408500
	111.43	**1696.90**	**960.62 (57%)**	**736.28 (43%)**	**235771**	**166056**	**401827**	**281827**
Conventional	66	0	0	66(100%)	0	214500	214500	114500
Percentage increase in net profit of the farmers								**146.14**

*Production cost @ ₹ 1,20,000/ha (for seed cane crop) & ₹ 1,00,000/ha (for conventional method)

mill for crushing (Table 11.2). The average net profit recorded for seed cane crop was ₹ 2,81,827 per ha, however it varied between ₹ 1,50,900 and ₹ 4,08,500 per ha which was much higher than the average net profit of ₹ 80,000 to 1,20,000 per ha earned by cane farmers in the study areas of U.P.

Intercropping in sugarcane enhanced profit and nutritional food security

The intercrops raised with autumn and spring cane provides an opportunity to the farmers to earn intermittent income from sale of crops harvested at 3 to 4½ months after sowing. Demonstration on intercropping with autumn and spring sugarcane under NFSM scheme (2017-18) of Ministry of Agriculture and Farmers Welfare, Govt. of India was conducted at farmers' fields in Sitapur and Lakhimpur Kheri districts of U.P. covering 20.0 ha area.

The highest net profit of ₹ 3,88,250/ha was earned in case of potato grown as intercrop with sugarcane and the lowest profit of ₹ 1,64,000/ha was earned by the farmers with maize intercropping (Table 11.3). The net profit for all intercrops was much higher than the profit recorded with sole cane crop.

Modulating application of sugarcane production technologies for harnessing production and productivity potential

The baseline data of sugarcane cultivation practices followed by growers in five villages of Lakhimpur Kheri district from 42 sugarcane growers were collected. The sugarcane cultivation practices revealed that they adopted various techniques for harnessing higher yield of sugarcane. For preparation of sugarcane field, the farmers were ploughing the cane field twice by harrow followed by 2-3 times by cultivator to have desired tilth. As far as sugarcane varieties were concerned, majority of them were growing Co 0238 (90%) followed by CoLk 94184, CoS 8431, CoS 767, Co 05011 and CoSe 98231. The seed treatment was done by the using Carbendazim 100 g + Imidacloprid 100 ml or Carbendazim 100 g + Imida Gold 100 ml/acre. Majority of the farmers followed flat planting method. Sugarcane growers were using 375 kg urea+125 kg DAP +100 kg muriate of potash and 25 kg zinc sulphate. They seldom use biofertilizers. They followed surface irrigation method. In case of plant protection, termite was controlled by Chloropyriphos, however, some of them also used bioagents like *Beauveria bassiana* and *Metarhizium anisopliae*. Top borer was controlled by applying Coragen 150 ml/acre.

Table 11.3. Economic analysis of intercropping with sugarcane (2017-18)

Cropping system	Yield (t/ha)		Return (₹/ ha)		Gross return (₹/ha)	Net profit (₹/ha)	% Increase in profit
	Cane	Intercrop	Cane	Intercrop			
Sugarcane + Vegetable Pea	90	7.5	292500	135000	427500	307500	141.18
Sugarcane + Potato	85	29.0	276250	232000	508250	388250	204.51
Sugarcane + Lentil	84	1.5	273000	72000	345000	225000	76.47
Sugarcane + Chickpea	82	1.95	266500	81900	348400	228400	79.14
Sugarcane + Mustard	83	1.60	269750	60800	330550	210550	65.14
Sugarcane + Maize	80	1.5	260000	24000	284000	164000	68.63
Sugarcane + Groundnut	84	1.6	273000	48000	321000	201000	57.65
Sugarcane + Pigeonpea	81	2.0	263250	100000	363250	243250	90.78

Sale price (₹/q): Vegetable pea- 1800; Potato- 800; Lentil- 4800; Chickpea- 4200; Mustard- 3800; Maize- 1600; Groundnut- 3000; Pigeonpea- 5000; Sugarcane - 325

Trichocard (*Trichogamma chilonis*) were also used by the farmers to control borers. The cane growers perform roguing in case of red rot and GSD. In ratoon crop, gap filling was carried out through use of either clump or two budded setts. A few followed trash mulching to conserve moisture and add organic matter in field. The sugarcane production technologies in regards to varieties, planting methods, intercropping with pulse crops, bio-control modules (pheromone traps for borer pests, release of egg parasitoids) were operationalized to make them applicable on farmers field. Instrument developed to make out preferential choices in regards to five attributes of technology modules *viz*, simplicity-complexity, cost of technology, profitability, physical compatibility and cultural compatibility.

Documentation and confirmation of indigenous technical knowledge in sugarcane based cropping systems

In total 80 farmers, 15 key informers (KIs) and 10 sugarcane development personnel were contacted to collect ITKs related to sugarcane cropping system in West Champaran and Motipur (Bihar). The prevailing cropping systems were Paddy-Mustard-Sugarcane-Ratoon, Paddy-Sugarcane+Potato, Paddy-Wheat-Sugarcane, Paddy-Lentil-Sugarcane. ITKs like soil fertility assessment by observing crops, soil type identification through observing pattern of clod formation, hardiness of clods (Slippery and very hard clods formation after drying indicate clay soil, clods get broken by hitting these by feet indicate loam and sandy loam). Keeping herds of animals in the fields at night for consecutive 15 to 30 days to tap dung and urine *in situ* and use of FYM and green manuring with sunhemp, *dhaincha*, mungbean for improvement of soil fertility as well as to reduce use of chemical fertilizers, indigenous method of planting by using two numbers of *desi* plough, indigenous sugarcane variety; Kavali having very low trash. Use of FYM 20-25 t/ha, earthing-up for lodging prevention, covering and sprinkling of water over harvested cane for preventing staling, mulching of trash to conserve moisture, use of trash as litter and composting, intercropping of pulse crops, intercropping of potato along with pulse crops, use of neem cake @ 1000 kg/ha for control of termite at the time of planting, summer ploughing, interculture operations with *desi* plough and digging with spade for weed control, irrigation of seed cane crop before seven days of harvesting for enhancing germination, sowing wheat by *pora* method, indigenous method of paddy seed storage and use of ash for control of gundhi bug were documented.

On-station demonstration

To showcase the cane production technology to dignitaries and visitors, on-station demonstration in one hectare area was laid out in Technology Park (Field No. E-39, IISR Farm). Planting methods, intercropping with sugarcane, IPM, cane node technique, plant growth regulator and cane varieties were demonstrated.

Frontline demonstrations

For fast spread of newly released cane varieties, twenty FLDs on seed cane production was conducted in farmers' fields on Sitapur, Lakhimpur Kheri, Barabanki, Ballia and Shrawasti districts of Uttar Pradesh and Motihari district of Bihar. Seed cane of varieties CoLk 94184, CoPK 05191, Co 05011, CoH 128, Co 0118, CoLk 09204, Co 0238, Co 98014, CoS 08272, Co 0232 and Co 0233 was raised in demonstration fields with recommended package of practices. Demonstrations on Ratoon promoter were conducted at farmers' fields in Biswan Sugar Mill, Sitapur (U.P.) covering 10 villages, 20 cane growers and 10 ha area.

Frontline demonstrations of ICAR-IISR developed equipments

(i) Frontline demonstrations of IISR tractor operated ratoon management device were conducted at farmer's fields in Sitapur district in 5.5 ha covering 12 farmers. Effective field capacity of the machine was 0.3 ha/h.

(ii) IISR tractor operated deep furrow sugarcane planter was demonstrated at farmers field of Muzaffarnagar; Lakhimpur Kheri, Bahraich districts of Uttar Pradesh and East Champaran, Muzaffarpur districts of Bihar in 12 ha area. The performance of the planter was satisfactory.

(iii) Trench planter was demonstrated at farmer's field in Barabanki, Lakhimpur Kheri, Hardoi and Lucknow districts. A total of 12 ha area was covered at field covering 10 farmers. The equipment plants one pair of rows at a spacing of 30 cm in the single pass. 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 in cane planting such as furrow opening, sett cutting, placement of cut setts into the furrows, application of fertilizer and insecticide, covering of setts with soil and pressing the covered soil in a single pass.

(iv) IISR tractor operated raised bed seeder-cum-sugarcane planter was operated at farmer's field at East Champaran and Muzaffarpur districts of Bihar and Lucknow in 5 ha area. 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 like wheat/pulses are sown on the two raised beds. Performance of the planter was satisfactory with field capacity of 0.20 ha/h.

Model farm in village of Sitapur district established

Model Farm Approach plays a key role in speedy transfer of technology to the farmers and also provides experiential learning opportunity to the clientele groups involved in a particular cropping system. Under ToT programme of the Institute, model farms were established in Khambapur and Bakhariya villages of Sitapur district in Uttar Pradesh. Model farms focussed on showcasing of entrepreneurship in seed cane production and intercropping with sugarcane to enhance farm productivity and income. Many interventions like trench planting, seed cane production techniques, scientific practices for raising intercrops, ratoon management, water saving irrigation techniques etc were introduced in model farms. Dignitaries, officials and many groups of farmers from different States have visited these model farms.

Technology and machinery demonstration mela

Technology and machinery demonstration mela was organized at ICAR- IISR, Lucknow on February 16, 2018. It was jointly organized by IISR, Lucknow; AICRP on Farm Implements & Machinery and Post Harvest Engineering and Technology. Total participants were more than 350 (mainly farmers from U.P.).

An exhibition was also organized on this occasion and IISR developed machineries and post harvest equipments were displayed. The field demonstration of sugarcane machinery namely Deep Furrow Sugarcane Cutter Planter, Trench Planter-cum-Bed Seeder and Deep Furrow Sugarcane-Cum-potato Planter was conducted. The demonstration of improved jaggery making technology namely three pan jaggery furnace, moulding frame and storage bin were also conducted. Farmers took keen interest in the machinery and equipments exhibited and demonstrated.

Transfer of technology for jaggery production

- A jaggery unit was installed at KVK, Piprakothi (Bihar) for demonstration of quality jaggery production and training to farmers. The unit was inaugurated by the Hon'ble Minister of Agriculture and Farmers' Welfare, Govt. of India, Sh. Radha Mohan Singh in presence of *Yoga Guru*, Baba Ramdev on June 9, 2017.
- Improved jaggery making technology was demonstrated to visitors at several occasions.
- Request for establishment of jaggery plant has been received from Regional Centre, Karnal; KVK, Kawardha; Sh. Harmanjeet Singh, Ludhiana, NASRAC, West Bengal; KVK, Gorakhpur, two entrepreneurs, Sh. Deshmukh and Sh. Nagendra from Pune with technical support.

Name of technology transferred / adopted	No of units	Address of farmers/ entrepreneurs/ manufacturers
IISR 3-pan jaggery unit	01	• KVK, Piprakothi, Motihari, Bihar
Moulding frame	40 set	• Sh. Rajendra Verma, Faizabad • Sh. Jagtar Singh, Amritsar • Sh. Kaushal Singh, Gurdaspur • Sh. Himanshu Gangwar, Farrukhabad • Sh. Manjeet Singh, Gurdaspur • Sh. Shamsher Singh, Hisar • Ms. Unati, Talwara, Punjab • Ms. Nitu Kaushik, Ghaziabad
Value added jaggery	02	• Ms. Nitu Kaushik, Ghaziabad • Sh. Yashu Bansal, Silliguri

Field day organised

Three field days were organized by IISR on February 25, 2018 at Dokti, Ballia; March 14, 2018 at IISR, Lucknow and March 25, 2018 at Biswan, Sitapur. More than 500 farmers, development officials, and sugar mill personnel participated in the event. Information in cane production technology was provided to the participants and *Vaigyanik-Krishak Paricharcha* was also facilitated to provide on-the-spot solution to the farmers.

Students visit under Inter-institutional HRD activities

Under inter-institutional HRD activity, visits of students and teachers from SHUATS, Allahabad; BHU, Varanasi; AMITY, Lucknow; Christian College, Lucknow; SRM College, Lucknow was conducted. About 500 UG/PG students visited ICAR-IISR. During visit, they were imparted information on IISR research infrastructure, achievements and technologies developed through orientation lecture and visit to labs and fields.

Participation in exhibitions

Date	Place	Organizer
April 13-19, 2017	Gandhi Maidan, Motihari, Bihar	ICAR-RCER, Patna
June 9, 2017	Krishi Vigyan Kendra, Piprakothi, East Champaran (Bihar)	ICAR-IISR, Lucknow
September 10, 2017	ICAR-IISR RC, Motipur (Bihar)	"*Sankalp Se Siddhi*" programme organized under New India Movement (2017-2022)
September 22-25, 2017	Pandit Deendayal Upadhyaya Dham, Mathura	Agriculture Exhibition of ICAR, Krishi Bhawan, New Delhi
October 5-8, 2017	All India Farmers Fair and Agricultural Industry Exhibition	CSAUA&T, Kanpur
November 30, 2017	ICAR-CISH, Lucknow	ICAR-CISH, Lucknow
December 02, 2017	ICAR-IIPR, Kanpur	ICAR-IIPR, Kanpur
January 31, 2018	*Kisan Mela*-2018	CSIR-CIMAP, Lucknow
February 14-15, 2018	International Agri. Expo 2018	Chandra Shekhar Azad University of Agriculture and Technology, Kanpur
February 23-25, 2018	North Zone Agriculture Mela-2018 in Deendayal Hastkala Sankul, Varanasi	ICAR-IIVR, Varanasi
March 16-18, 2018	*Krishi Unnati Mela*– 2018	ICAR-IARI, Pusa, New Delhi

Outreach activities in technology management

Programme Organized for Technology Commercialize/ Transfer	Number of Participants	Venue
Jaggery entrepreneurship development	500 farmers	ICAR-IISR, Lucknow Regional Station, Motipur (Bihar)
Follow up visits	Three visits	Firms having MoUs with the Institute
All Scientists of the Institute	At least one visit by each of 13 teams per quarter	Sitapur, Hardoi, Barabanki and Raebareli

CHAPTER 11

Krishi Vigyan Kendra

Technology Assessment

Following technologies were assessed during the year 2017-18:

Thematic areas	Crop	Name of the technology assessed	No. of trials	No. of farmers
Nursery management	Tomato/ Brocoli	T_1Farmer practice-Excess use of seeds on flat bed T_2Nursery bed, soil solarization, use of bio-pesticides	3	3
Production management technology	Tomato	T_1-Farmers' practice T_2-Plastic mulch	3	3
Honey production	-	T_1-Farmers' practice - Only honey production T_2-Propolis production with honey	5	2
IPM	Mango	T_1-Farmers' practice-Injudicious use of pesticides T_2-Spray of Flubenzamide 24 EC (0.4 gm./lit)	3	3
Drudgery reduction	Mango	T_1-Mango harvesting through shaking and jarring T_2-Mango harvesting through traditional harvester T_3-Mango harvesting through CISH harvester	3	3
Women & child care	-	T_1- Jaggery T_2- Value added jaggery	3	3
Fodder		T_1-Farmers' practice- Berseem–*Jower chari* T_2-Perennial fodder grasses T_3-Sorghum-maize– cowpea	5	5
Dairy	Low milk yield	T_1-Farmers' practice- wheat bran + *chuni* + oilcake T_2- 50 gm powder of shatavari roots	3	3

Evaluation of mulching in vegetable crops

Keeping in view of the resource conservation technologies, evaluation of mulching materials in vegetable crop production was undertaken. The results revealed that application of mulching materials plastic/ organic significantly enhanced the seedling production in connection with quantity and quality both. The maximum yield (517.5 q/ha) was recorded with plastic mulch with benefit cost ratio of 1 : 2.6.

Management of vegetable nursery for healthy seedling

Presently, farmers are using hybrids in vegetable crops for higher remuneration per unit of area. Farmers of Lucknow district generally grow vegetable nursery in traditional way on flat bed by seed broadcasting, which result in unhealthy seedling & high mortality and increases cost of seedling production. In these circumstances, the present study was conducted at farmers' field using treatment of nursery bed, soil solarization and use

Technology option	Healthy seedling (%)		No. of healthy seedling/m²	
	Tomato	Broccoli	Tomato	Broccoli
Farmers' practice-Excess use of seeds on flat bed	65.7	68.5	113	122
Nursery bed, soil solarization, use of bio-pesticides	93.5	95.8	205	212

of bio-pesticides. The results revealed that production of seedling was higher in comparison to farmers' practice.

Additional income from honeybee production

Rural youth of Lucknow district are involved in beekeeping to earn money from honey. Beekeeping also have some secondary sources of earning like pollen collection or propolis collection etc. So keeping this in view, a study for extra income in beekeeping was conducted at farmers field. Results revealed that farmers earned ₹ 2668 per box per year extra. Details are as follows:

Technology option	Yield (q/ha)	Gross cost (₹)	Gross income (₹)	Net income (₹)	B:C
T_0: Farmers' practice	390.2	114500	195100	80600	1.7
T_1: Organic mulch	482.8	105900	241400	135500	2.3
T_2: Plastic mulch	517.5	98400	258750	160350	2.6

Technology option	No. of trials	Honey production (kg/box)	Propolis production (kg/box)
T_1-Farmers' practice - Only honey production	5	61.50	-
T_2-Propolis production with honey		64.70	2.85

Technology option	No. of trials	% inci-dence	Avg. yield of mango crop (q/ha)	Quality yield (q/ha)
T_1-Farmers' practice-Injudicious use of pesticides	5	16. 53	98.0	81.2
T_2-Spray of Flubenzamide 24 EC (0.4 gm/l)		5.40	126.7	122.5

Economics

Technology option	Gross cost (₹)	Gross income (₹)	Net income (₹)	B:C
T_1-Farmers' practice-Injudicious use of pesticides	38000	81200	43200	2.13
T_2-Spray of Flubenzamide 24 EC (0.4 gm/l)	41400	122500	81100	2.96

Management of leaf webber in mango orchards

Lucknow district is famous for mango cultivation but heavy incidence of mango leaf webber (*Orthaga euadrusalis*) is being witnessed for the last few years. An on-farm trial was conducted for its control in effective and economical manner. Results revealed that minimum incidence of leaf webber (5.40%) was noticed in demonstrated technology in comparison with farmers practice (16.53%).

Evaluation of efficiency and drudgery of mango harvesters for picking of mango

KVK, Lucknow assessed the efficiency of improved mango harvester and drudgery reduction in comparison to farmers practices. Result revealed that improved CISH harvester was found more efficient and having drudgery reduction.

Mobile advisory services

No. of calls	No. of farmers	No. of messages
138	37580	50

Frontline demonstrations

Enterprise	No. of farmers	Area (ha)	Units/ Animals
Oilseeds	81	15	-
Pulses	324	62	-
Cereals	82	16	-
Vegetables	105	15	-
Other crops (fodder crops)	80	13	-
Total	**672**	**121**	-
Livestock & Fisheries	115 families	-	250
Grand Total	787	121	500

Seed & planting material production

Particulars	Quintal / number	Value (₹)
Seed (q)	53	2,09,000
Planting material (No.)	50,50,000	68,050
Bio-products (q)	58.07	34,780
Pickles (q)	0.94	11,280

Soil analysis

Samples	No. of beneficiaries
370	970

Effect on milk production through availability of green fodder round the year

For enhancing the milk production in Lucknow district, there is need to provide green fodder availability round the year to milch animals. So, an on-farm trial was conducted. The results revealed that perennial fodder grasses provided green fodder for 300 days and per cent increase in milk was 24% followed by Farmers Practices-*Berseem–Jower–Chari* (228 day) and minimum availability of green fodder (175 days) in Sorghum–Maize–cowpea cropping system.

Effect of *Shatavari* (*Asparagus racemous*) feeding on milk production in lactating cows : An on farm trial was conducted to evaluate the effect of feeding *Shatavari* (*Asparagus racemous*) on milk production in lactating cows (parturated in 1 to 4 months). Total 15 cows (cross breed) were selected and fed 50g powder of *Shatavari* roots in concentrate once in a day for a period of 60 days. The overall milk production increased 1.06 +0.17 kg (11.47%) daily and average milk production were increased 1032 +0.15 kg (12.72%) as compared to farmer practice. Increase in the income by feeding *Shatavari* comes to ₹ 7.49/day/animal and BC ratio was 1:3.

Technology option	No. of trials	Production of different fodder (q/ha)	Total no. of days for production of fodder	Average production (q/ha)	Cost of cultivation (₹/ha)	Gross income (₹/ha)	Net income (₹/ha)	B:C
T_1-Farmers practices-*Berseem–Jowar–Chari*	**5**	*Berseem* –450 *Jowar*–250 *Chari*–310	228	333.33	35990.0	116665.5	80675.5	3.24
T_2-Perennial fodder grasses		620	300	445.67	25700.0	85845.0	60145.0	3.34
T_3-Sorghum-Maize– Cowpea		Sorghum–250 Maize–180 Cowpea-220	175	444.75	25410.0	75845.0	50435.0	2.98

Details of extension activities

Activity	No. of programmes	No. of farmers	No. of extension personnel	Total
Advisory services	135	-	-	-
Diagnostic visits	18	155	-	155
Field day	8	160	-	310
Group discussions	15	180	20	200
Kisan Goshthi	6	800	-	800
Film Show	25	300	16	516
Kisan Mela	1	675	25	700
Exhibition	5	5850	30	6530
Scientists' visit to farmers field	125	1225	-	1225
Farmers' seminar/Workshop	1	500	25	525
Method of demonstrations	24	445	-	445
Celebration of important days	4	152	-	175
Animal camp	1	80	2	82
Special day celebration	1	50	-	50
Total	**369**	**10604**	**118**	**10722**

CHAPTER 12

Services to the Industry

Contract research

ICAR-IISR, Lucknow carried out the evaluation of some new industrial products which have the use in sugarcane cultivation. The evaluation of products such as insecticides, herbicides, weedicides, fungicides, seed material and other chemical formulations has been carried out on sugarcane crop. The evaluation was carried out signing a MoU with the company or agency as per details given below (Table 12.1):

Table 12.1. MoUs for Contract Research

Title of the project	Sponsoring agency	Investigators	Date of start	Date of completion	Budget (₹ in Lakh)
Evaluation of PII 8007 20% SC against termites and cane borers of sugarcane and its effect on bio-agents	PI Industries Limited	Dr. M.R. Singh	May 2017	April 2018	7.5
Bio-efficacy, phytotoxicity and carryover effect of halosulfuron-methyl 75% WG against major weeds of sugarcane	Coromondel International Limited	Dr. V.P. Singh	March 2017	December 2018	5.0
Bio-efficacy evaluation of Ametryn 80% WDG herbicide against weed complex of sugarcane	ADAMA India Private Limited	Dr. V.P. Singh	March 2017	December 2019	8.0
Bio-efficacy evaluation of SL-160 10% WO herbicide against weed complex of sugarcane	ISK Biosciences India Private Limited	Dr. V.P. Singh	March 2017	December 2019	10.0
Assessing efficiency of PROM (Phosphorus rich organic manure) as on organic source of P on the productivity of wheat-greengram–rice cropping system	Narmada Biochem Limited	Dr. S.N. Singh, Dr. A.D. Pathak, Dr. V.K. Singh, Dr. R.K. Singh, Dr. Y.P. Singh	March 2017	March 2019	10.0
Field bioefficacy and phytotoxicity evaluation of Flumioxazin 50% SC against weeds in sugarcane and its effect on succeeding crop	Sumitomo Chemical India Pvt. Ltd., New Delhi	Dr. V.P. Singh, Dr. K.K. Singh, Dr. V.P. Jaiswal, Dr. S.K. Shukla	October 2016	August 2019	10.0
Bio-efficacy and phytotoxicity evaluation of RJKP 1505 (2, 4–D Sodium Salt 67.7% + Metribuzin 16.5% WG) in sugarcane	Atul Limited, Valsad	Dr. V.P. Singh, Dr. K.K. Singh, Dr. A.K. Singh, Dr. S.K. Shukla	March 2016	August 2018	8.0
Evaluation of bioefficacy of Solomon 300 OD (Betacyfluthrin 90 + Imidacloprid 210 OD) against black bug and cane borers of sugarcane and its effect on natural enemies and sugarcane crop	Bayer Crop Science Ltd., Mumbai	Dr. M.R. Singh, Dr. Arun Baitha	April 2016	March 2018	7.5
Bio-efficacy evaluation of tembotrione 420 SC (laudis 420 SC) in sugarcane	Bayer Crop Science Ltd., Mumbai	Dr. V.P. Singh, Dr. K.K. Singh, Dr. S.N. Singh, Dr. S.K. Shukla	February 2016	January 2018	8.0
Field bioefficacy and phytotoxicity evaluation of Atrazin 50% WP against weed complex in sugarcane	Meghmani Organics Ltd., Ahmedabad	Dr. K.K. Singh, Dr. V.P. Singh, Dr. S.K. Shukla	October 2016	July 2017	5.0
Field bioefficacy and phytotoxicity evaluation of Ametryn 80% WG against weed complex in sugarcane	Meghmani Organics Limited, Ahmedabad	Dr. K.K. Singh, Dr. V.P. Singh, Dr. V.P. Jaiswal	October 2016	July 2018	5.0
Evaluation of Atrazine 50% WP against weeds in sugarcane	SDS Ramcides Crop Sciences Pvt. Ltd., Chennai	Dr. V.P. Singh, Dr. V.K. Singh, Dr. S.K. Shukla, Dr. T.K. Srivastava	August 2016	July 2017	3.0

CHAPTER 13

Training and Capacity Building

Capacity building programme for cane managers of sugar industry

A 15-days training on Sugarcane Management and Development for cane development personnel of sugar mills was organized from July 1-15, 2017. Twenty four cane managers/officers from different sugar mills participated in this training. The major objective

of this training was to groom cane development officers of sugar mills in latest cane production and processing technology, update them in marketing and development strategy. Accelerate large-scale adoption of sugarcane technologies in sugar mill zone areas was also targeted by grooming and developing cane managers/officers of sugar mills into "torch-bearer" of ICAR-IISR technologies.

ICAR sponsored 10-days Short Course organised

ICAR sponsored 10-days Short Course on "Modern genomic tools and breeding strategies for biotic and abiotic stress management in sugarcane"

was organized at ICAR-Indian Institute of Sugarcane Research, Lucknow from Oct. 25 to Nov. 03, 2017. Dr. Sanjeev Kumar, Principal Scientist (Agril. Biotechnology) was Course Director. Fifteen candidates including two women candidates participated.

In the 10 days of training, a total of 20 lectures and 10 practical sessions were held. The lectures were mainly related to breeding for biotic and abiotic stress management, phenotyping of sugarcane, mapping populations, advancements in cytology, molecular markers, DNA barcoding, sequencing techniques, functional genomics, genome editing, bioinformatics, DNA based diagnostics and IPR issues. The practical session was related to genetic fidelity testing using ISSR markers and ELISA for virus detection.

The Short Course ended on November 03, 2017. Dr. R.K. Singh, ADG (CC), ICAR, New Delhi graced the valedictory session. The compendium of the lectures including laboratory protocols in the form of a Training Manual was released on this occasion.

Sensitization Workshop on "Intellectual Property, Technology Management & Entrepreneurship Development" organized

A Sensitization Workshop on "Intellectual Property, Technology Management & Entrepreneurship Development" was organized at ICAR-Indian Institute of Sugarcane Research, Lucknow on March 22, 2018. Dr. K.K. Lal, Director, ICAR-National Bureau of Fish Genetic Resources (NBFGR), Lucknow deliberated on the evidence of protection of tangible properties in ancient Indian literature. Now, this is high time to protect our intangible properties and to commercialize them. Dr. A.D. Pathak, Director, ICAR-Indian Institute of Sugarcane Research, Lucknow informed that the IISR has developed many technologies and has commercialized through licensing. Dr. Pathak hoped that the deliberations of the Workshop will certainly be helpful in sensitizing the researchers. Dr. L.S. Gangwar, Principal Scientist, ICAR-IISR, Lucknow highlighted the theme of the Workshop. Dr. A.C. Shukla, Professor, Lucknow University, Lucknow gave a presentation on various aspects of patenting. Dr. Neelima Garg, Head, Division of Post Harvest Management, ICAR-CISH, Lucknow presented a brief overview about the technologies developed at CISH, Lucknow. Dr. Poonam Jayant Singh, Sr. Scientist, ICAR-NBFGR, Lucknow presented the method of technology

management adopted in US and UK. Dr. A.K. Sharma, Principal Scientist, ICAR-IISR, Lucknow highlighted the prevailing environment in the country to initiate a new start up. He informed that the Government has come up with many policies to encourage the entrepreneurs. Dr. Dilip Kumar, Principal Scientist, IISR, Lucknow highlighted the immense potential for entrepreneurship development in jaggery sector.

Training programme on "Development of soft skills for attaining excellence in science" organized

One day training programme on "Development of soft skills for attaining excellence in science" was organized at ICAR-IISR Lucknow on September 12, 2017. Dr P.K. Chhonkar, Adjunct Faculty, IARI and Ex-Head delivered the interactive talks spread in three sessions. The interactive lectures highlighted the importance of soft skills in improving work culture, interpersonal relationship, communication skills, importance of EQ and physical and mental fitness in research and development. Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow welcomed the participants and other dignitaries. Dr. P.S. Pathak, former Director, ICAR-IGFRI, Jhansi and Convener, NAAS, Lucknow Chapter introduced the speaker. Dr. K.K. Lal, Director ICAR-NBFGR, Lucknow and Dr D.K. Sharma former Director, ICAR-CSSRI, Karnal graced the occasion. Scientists from ICAR-IISR, ICAR-NBFGR and ICAR-CSSRI RS, Lucknow attended the programme.

Dr Amaresh Chandra, Organizing Secretary proposed the vote of thanks.

Training programme on mechanization

A three day's training programme on "Mechanization of sugarcane cultivation" was conducted for the fifteen sugarcane growers of the Uttar Pradesh from October 10-12, 2017.

One day training-cum-visit organised

During 2017-18, a total of 81 nos. one day training and visit programme were organized at the Institute in which more than 2313 farmers, 76 development personnel, 473 students and 21 teachers acquired latest know-how in scientific cane cultivation practices.

Skill development residential training organised

A total of 20 residential skill development training for different clientele groups was organized in which 655 farmers, entrepreneurs, students and development personnel participated. They were trained in latest cane production techniques, seed cane production, advances in sugarcane research and ways and means to enhance income from sugarcane based production systems including jaggery making.

Skill development training organized

Name of Training	Topic	Duration	Sponsoring agency	No. of participants
7-days training	Advances in Sugarcane Research and Development	May 19-25, 2017	Students of B.Sc. (Ag), IAS, BHU, Varanasi	38
15-days students training	Orientation in Sugarcane Research and Management	June 15-29, 2017	Students of Mewar University, Rajasthan	17
15-days National Training	Sugarcane Management and Development	July 01-15, 2017	Sugar Mills	24
8-days MTC	Entrepreneurship in sugarcane based production system to double farmers'	October 6-13, 2017		20
2-days National Training	**Sugarcane Production Technology for Higher Cane Yield and Profitability**	November 06-07, 2017	DAC & Farmers' Welfare, Ministry of Agriculture and Farmers Welfare, Govt. of India	25
2-days National Training		November 09-10, 2017		25
2-days National Training		December 19-20, 2017		25
2-days National Training		December 22-23, 2017		25
2-days National Training		December 27-28, 2017		25
2-days farmers training	Sugarcane Production Technology	December 22-23, 2017	ATMA, Vadodara (Gujarat)	53
4-months students training	Agro-Industrial Attachment & RAWE	September 05, 2017 to January 05, 2018	Students of Mewar University, Chittorgarh, Rajasthan	06 B.Sc. (Ag.) Students
5-days training for Extension personnel	*Ganna Utpadan Takneek*	November 13-17, 2017	State Agriculture Management Extension Training Institute, Lucknow	35
4-days training	Sugarcane production technology	October 30, 2017 to November 02, 2017.	Cane Dev. Deptt., Govt. of Andhra Pradesh	70 sugarcane farmers and sugar factory officials
10-days officers training	Entrepreneurship in sugarcane sector to double farmers' income	March 19-28, 2018	MANAGE, Hyderabad	20 participants
One day training	Bud – chip technique in sugarcane	February 21, 2018	ITC, Saharanpur,	7 NGO staff
One day farmers training	*Ganna Utpadan Takneek*	February 25, 2018 at Dokti, Ballia (U.P.)	DSD, Lucknow	80
One day farmers training	*Ganna Utpadan Takneek*	March 14, 2018 at IISR, Lucknow	DSD, Lucknow	80
One day farmers training	*Ganna Utpadan Takneek*	March 25, 2018 at Biswan, Sitapur (U.P.)	DSD, Lucknow	80
				655

Entrepreneurship training for promoting agri-business

The entrepreneurship in agriculture has been identified as significant contributing factor in doubling or enhancing farm income. The Institute has applied concerted efforts under its outreach extension and training programme to impart the knowledge and skills in entrepreneurship to farmers, NGO personnel, development officers, Agri-graduates and extension functionaries of different state governments. For these, several residential and off campus training programmes were conducted in which more than 1000 participants were groomed as entrepreneur to pursue agr-business in their available farming systems.

Capacity building of IISR Staff

Name	Training	Venue	Date
Mr. Rajiv Kumar	Professional attachment training on "Characterization of stress-associated genes/ proteins for the screening of wheat germplasm for thermo-tolerence"	ICAR-IARI, New Delhi	May 22-August 23, 2017
Mr. Ashish Singh Yadav	Training programme on "Competence Enhancement Programme on Soft Skills and Personality Development for Technical Staff"	ICAR-NAARM, Hyderabad	June 15-24, 2017
Dr. Y.P. Singh	Training Programme	ICAR-ATARI, Kanpur	August 9-10, 2017
Dr. M. Swapna	Training Programme on "Application of Bioinformatics in Agriculture and Education"	ICAR-NAARM, Hyderabad	September 14-23, 2017
Mr. Atul Kumar Sachan	Training on "Network : Basics and Management"	ICAR-IASRI, New Delhi	September 4-8, 2017
Mr. Atul Kumar Sachan	Training on Competence Enhancement Programme on Motivation and Positive Thinking	ICAR-NAARM, Hyderabad	September 11-20, 2017
Dr. A.D. Pathak and all the Scientists of the Institute	Development of Soft Skills for attaining Excellence in Science	ICAR-IISR, Lucknow	September 12, 2017
Dr. Lalan Sharma, Dr. Dilip Kumar, Dr. S.K. Yadav, Dr. Dilip Kumar, Mr. Brahm Prakash and Mr. Atul Kumar Sachan	Short Course on Modern Genomic Tools and Breeding Strategies for Biotic and Abiotic Stress Management in Sugarcane	ICAR-IISR, Lucknow	October 25 – November 3, 2017.
Dr. A.K. Sah	Training on Linking Extension with Agro-tourism and Agripreneurship	MANAGE, Hyderabad	December 4-7, 2017
Mr. A.K. Sachan, Mr. K.N. Singh, Mr. C.P. Singh, Mr. Ashish Singh Yadav, Mr. Rakesh and Mr. Inder Singh	Training on Sugarcane Production Technology for Higher Cane Yield and Profitability	ICAR-IISR, Lucknow	December 22-23, 2017
Mr. Kapil Dev Pandey	Training programme on "KOHA for Library Staff of ICAR"	ICAR-NAARM, Hyderabad	February 5-9, 2018

CHAPTER 14

Awards and Recognitions

Institute Recognition

- Institute's *Rajbhasha Patrika "Ikshu"* bagged *Rajbhasha Kirti Puraskar* (First Prize) for the year 2016-17 in the '*Ka*' region. Dr. A.D. Pathak, Director received the award of Ministry of Home Affairs, Govt. of India by the Hon'ble President of India in the ceremony held on September 14, 2015 at Vigyan Bhawan, New Delhi.

- Institute's *Rajbhasha Patrika "Ikshu"* bagged *Ganesh Shankar Vidhyarthi Puraskar* (First Prize) of Indian Council of Agricultural Research for the year 2016-17. Dr. A.D. Pathak, Director received the award by the Hon'ble Minister of Agriculture and Farmers Welfare, Govt. of India on the occasion of ICAR Foundation Day on July 16, 2017 at NASC Complex, New Delhi

- ICAR-Indian Institute of Sugarcane Research, Lucknow received Mahindra Samriddhi India Agri Awards 2018 for Public Sector Research Organization on March 06, 2018 at Hotel Ashoka, New Delhi. Dr. A.D. Pathak, Director received the award from the Chief Guest, Shri Radha Mohan Singh, Hon'ble Union Minister of Agriculture and Farmers Welfare, Govt. of India.

- The Krishi Vigyan Kendra, ICAR-IISR, Lucknow was conferred the Best KVK (Zonal) award of *Pandit Deendayal Upadhyay Rashtriya Krishi Vigyan Protshahan Puraskar* 2017 by the Hon'ble Prime Minister of India at the inaugural function of *Krishi Unnati Mela* 2018 at ICAR-IARI, New Delhi on March 17, 2018. This award was received by Dr. A.D. Pathak, Director and Dr. S.N. Singh, Head, KVK of ICAR-IISR, Lucknow from the Hon'ble Prime Minister of India at the above function.

Personal Recognition

- Dr. Rajesh Kumar, Principal Scientist & I/c, AKMU was conferred upon Award for Excellence in Research by the Education Expo TV's Research Wing for Excellence in Professional Education & EET CRS.
- Dr. Rajesh Kumar, Principal Scientist & I/c, AKMU was conferred upon 5th Industry Science & Technology Award-2017 for his contributions in the field of Sugarcane Research, Science and Technology on June 11, 2017 at Four Points by Sheraton, Whitefield, Bangalore.

- Dr. Rajesh Kumar, Principal Scientist & I/c, AKMU was conferred *Dr. Jamuna Prasad Yadav Vishisht Krishi Vaigyanik Puraskar* of Uttar Pradesh Academy of Agricultural Sciences for his outstanding contribution in the field of Statistics and Sugarcane Improvement during 28th Foundation Day Celebration of UPCAR on June 14, 2017 at ICAR -IISR, Lucknow.

- Dr. Rajesh Kumar, Principal Scientist & I/c, AKMU was conferred Industry Excellence Award for contribution in the field of Sugarcane Research, Science and Technology and Application of Statistics in Agriculture by the North Indian Sugarcane and Sugar Technologists' Association (NISSTA) during Annual Convention and Technical Expo (2017) on May 12 -13, 2017.
- Dr. Rajesh Kumar was awarded the honour of Fellow - 2017 of North Indian Sugarcane and Sugar Technologists' Association for his outstanding contributions in the field of sugarcane research, science and technology and application of statistics in agriculture.
- Dr. A.K. Mall, Senior Scientist was conferred *Dr. Basant Ram Vishisht Yuva Vaigyanik Puraskar* by Uttar Pradesh Academy of Agricultural Sciences on the occasion of 28th Foundation Day Celebration of UPCAR on June 14, 2017 at ICAR -IISR, Lucknow.
- Dr. A.K. Mall received Best Scientist (Research) Award-2018 by the Society for Scientific & Social Development on February 24, 2018.

- Dr. A.K. Mall received Young Professional Award 2017 by the Society for Community Mobilization for Sustainable Development, New Delhi on November 10, 2017.
- Dr. A.K. Mall received Teaching and Research Excellence 2017 by IRDP Group of Journals on October 14, 2017.
- Dr. A.K. Mall received Excellence in Research Award 2017 by Science and Tech Society for Integrated Rural Improvement on September 9-10, 2017
- Dr. A.K. Mall received Best Young Scientist 2017 (International Journal of Tropical Agriculture and Serial Publication (P) Ltd.) on June 24-25, 2017.
- Dr. M. Swapna was felicitated by the International Association for Professionals in Sugar and Integrated Technologies (IAPSIT), with the Distinguished Scientist Award for her contributions to Sugarcane Improvement at 6th IAPSIT International Conference, IS-2018 held at Udon Thani, Thailand on March 6-9, 2018.
- Dr. S.N. Singh, Principal Scientist was conferred the Best Scientist Award by the Executive Council of the Society of Agricultural Professionals (C.S. Azad University of Agriculture and Technology, Kanpur) for his outstanding contributions in sugarcane research and development during International Conference and AgriExpo 2018 (AGRICON).
- Dr Amaresh Chandra received Letter of Appreciation in 2017 from Indian Society of Agricultural Biochemists, C.S. Azad University of Agriculture & Technology, Kanpur for the most significant and outstanding achievements in the areas of Plant Physiology and Biochemistry.
- Dr. A.K. Sah received Dr. K.N. Singh Memorial Award from Indian Society of Extension Education, New Delhi in ISEE National Seminar on Doubling Farmers' Income and Farm production through Skill Development and Technology Application

held at Bihar Agricultural University, Bhagalpur on November 28-30, 2017.

- Dr. A.K. Sah received Excellence in Appreciation Award from SVWS in National Seminar on Farmer Centric Cinema held on October 14-16, 2017, jointly organized by SVWS and ICAR-IISR, Lucknow.
- Dr. A.K. Singh, Principal Scientist, Division of Crop Production was elected as Fellow of UPAAS for his outstanding contributions in the field of Natural Resource Management on the occasion of 28th Foundation Day Celebration of UPCAR on June 14, 2017 at ICAR -IISR, Lucknow.
- Dr. Rakesh Kumar Singh, SMS, Animal Science received "Excellence in Research Award" from Samagra Vikas Welfare Society in National Seminar on Farmer Centric Cinema held on October 14–16, 2017, at ICAR-Indian Institute of Sugarcane Research, Lucknow.
- The paper entitled "Upscaling bio-ethanol production - Research efforts and future plans" by Pushpa Singh, A.D. Pathak, Rama Kant Rai and Rajesh Kumar was awarded the Best Paper Award in Annual Convention and Technical Expo (2017) of NISSTA held during May 12-13, 2017 at ICAR–IISR, Lucknow.
- Dr. Sukhbir Singh and Dr. AK Singh received best poster award for their paper entitled, "Mechanization of furrow opening, interculturing and earthing up operations in sugarcane" during International Symposium on Sugarcane Research Since Co 205: 100 Years and Beyond (SucroSym 2017).
- A research paper entitled "Halophilic PSB for enhancing productivity of crops" by S.N. Singh was adjudged the Best paper during poster presentation in International Conference and AgriExpo 2018 (AGRICON) at C.S. Azad University of Agriculture and Technology, Kanpur during February 14-17, 2018.
- The paper entitled "Mixed model analysis in sugarcane varietal evaluation programme in India" by Rajesh Kumar, A.D. Pathak and Bakshi Ram was conferred with Best Poster Award in the International Symposium on Sugarcane Research Since Co 205: 100 Years and Beyond (SucroSym 2017) organized by ICAR-Sugarcane Breeding Institute, Coimbatore during September 18-21, 2017.
- Drs. Chandra Gupta, S.K. Shukla, Ishwar Singh and V.P. Jaiswal was conferred with the Best Research Paper Poster Award on their paper entitled "Effect of different planting methods and irrigation scheduling with mulch on yield and water use efficiency of spring planted sugarcane" at the International Symposium on Sugarcane Research Since Co 205: 100 Years and Beyond (SucroSym 2017) organized at ICAR-SBI Coimbatore during September 18-21, 2017.
- Dr. V.K. Singh was conferred with the Best Poster Presentation Award on his paper "Study the extent of participation and empowerment of rural women in mushroom cultivation in rainfed condition of Jharkhand" in National Convention-cum-Seminar 2017 on Doubling farmers' Income & Farm profitability by 2022 organized by BBAU, Lucknow on October 28-29, 2017.
- Dr. Rakesh Kumar Singh, SMS, Animal Science received "Best Paper Award" for oral presentation of research paper "Study of economic dairy farming in rural area of Lucknow district" in National Convention-cum-Seminar 2017 on Doubling Farmers' Income & Farm Profitability by 2022 organized by BBAU on October 28-29, 2017.
- Dr. Amaresh Chandra was nominated as Associate Editor of *Acta Physiolgiae Plantarum*, Consulting Editor of SugarTech and Member, Editorial Board of *SugarTech* Newsletter.
- Dr. Sangeeta Srivastava served as Chief Editor, *Indian J. Sugarcane Technology* (ASTI Journal), and as Editorial Board Member of *Journal of Environmental Biology*, *Indian Journal of Fundamental and Applied Life Sciences*.
- Dr. M. Swapna served as Editorial Board Member of *Sugar Tech Newsletter*, and as Reviewer for the journals, *Sugar Tech*, and *Physiology & Molecular Biology of Plants*.
- 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 was nominated as Member, Agriculture and Food Processing Equipment Sectional Committee, FAD 20 of Bureau of India Standards, New Delhi
- Dr. P.K. Singh was nominated for the Committee constituted for the finalization of Guidelines for effective implementation of "Access to Biological Resources and Associated Knowledge and Benefits Sharing Regulations, 2014" under Biological Diversity Act, 2002 regarding sugarcane in U.P.
- Dr S.I. Anwar acted as Secretary of Lucknow Chapter of Indian Society of Agricultural Engineers (ISAE).

CHAPTER 15

Publications

Research Papers

Anwar SI, Sharma K, Lal A and Singh P. 2017. Development and quality evaluation of bagasse fibre mixed jaggery based cookies. *Food Science Research Journal* **8**(2): 223-229.

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M.Sc. Thesis of Mr. Sateesh Yadav entitled "Biology of sugarcane adapted strain of *Trichogramma chilonis* (Hymenoptera: Trichogrammatidae)" was awarded for the degree of the Master of Science in Plant Protection (Entomology) from CCS University, Meerut under supervision of Dr. M.R. Singh, Head, Division of Crop Protection.

CHAPTER 16

Technical Programme (2017-18)

Project Code No.	Title of the project
I. Division of Crop Improvement	
B 1.7	Collection, maintenance, evaluation and documentation of sugarcane germplasm under sub-tropical conditions (P.K. Singh, Sanjeev Kumar and J. Singh; 01/95-LT)
B 1.8	Defining ideotypes in sugarcane for moisture deficit conditions (A.K. Mall, D.R. Malaviya and S.P.Singh; 03/18-03/21)
B 2.9	Development of top borer tolerant genetic stocks of sugarcane (A.D. Pathak, R.K. Rai, Sangeeta Srivastava, M.R. Singh, Rajesh Kumar and A.K. Mall; 03/2K-10/18)
B 2.1	Development of sugarcane varieties for sub-tropics (J. Singh, D.K. Pandey, P.K. Singh, Sanjeev Kumar and T.K. Srivastava; 10/03-LT)
B 2.14	Development of breeding stocks of sugarcane for durable resistance to red rot (D.K. Pandey, P.K. Singh, Deeksha Joshi, J. Singh and Sanjeev Kumar; 10/04-10/17)
B 2.15	Developing sugarbeet varieties for Indian agro-climates (A.D. Pathak, S.K. Duttamajumder, Arun Baitha and A.K. Mall; 09/08- LT)
B 2.16	Development of waterlogging tolerant and red-rot resistant sugarcane clones for North Central Zone (Sanjeev Kumar and S.K. Holkar; 2012-2018)
B 3.17	Elucidation of species chromosomal complement in sugarcane genotypes under sub-tropical conditions (Sangeeta Srivastava and A.D. Pathak; 06/10-05/18)
B 3.18	Identification and expression analysis of resistance gene analogues against red rot disease in sugarcane (Sangeeta Srivastava; 01/10-3/18)
B 3.19	Mapping of loci linked to sugar content in sugarcane (M. Swapna, D.K. Pandey and A.K. Mall; 12/09-03/20)
B 3.21	Production of disease free and genetically pure seed cane through tissue culture techniques (Sanjeev Kumar, J. Singh and S.K. Holkar; 11/13-LT)
B 3.22	Development of *in vitro* conservation protocol using slow-growth tissue culture techniques in sugarcane (Sanjeev Kumar (Biotech.) and J. Singh; 03/15-03/18)
B 3.23	Profiling and prediction of small RNA transcriptomes in sugarcane in sugarcane inoculated with red rot pathogen (Sangeeta Srivastava, A.D. Pathak and Dinesh Singh, 04/15-03/20)
AICRP on Sugarcane trials	
B 1.1	Evaluation of early maturing sugarcane clones of North West Zone (J. Singh and D.K. Pandey; 02/09 – LT)
B 1.2	Evaluation of mid-late sugarcane clones of North West Zone (J. Singh and D.K. Pandey; 02/09 to LT)
B 1.3	Evaluation of sugarcane clones under Zonal Varietal Trials for North Central and Eastern Zone (A.K. Mall and A.D. Pathak; 02/09 to LT)
II. Division of Crop Production	
A 1.1.32	Validation of cane node technology under farmers' field condition (S.N. Singh, A.K. Sah and C. Gupta; 02/16-02/19)
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 and A.P. Dwivedi; 04/17 – 03/22)

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; 2017 – 2022)
A 2.37	Sugarcane productivity in relation to initial soil organic carbon content and nutrient management in sub-tropical inceptisol (T.K. Srivastava, K.P. Singh, S.R. Singh, Pushpa Singh and R.R. Verma; 3/15 - 6/18)
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 (Agron.) and R.S. Dohare; 03/15-03/18)
A 2.39	Synchronizing nutrient supply with crop demand under drip fertigation for upscaling nutrient use efficiency in sugarcane (Plant) ratoon system (K.K.Singh, S.R.Singh, V.P.Singh, S.K.Shukla and Rajendra Gupta; 2017-2022)
A ET 1.1	Modulating application of sugarcane production technologies for harnessing production and productivity potential in farmers' field perspective (R.S. Dohare, T.K. Srivastava, Rajesh Kumar, S.N. Singh; 04/15 – 03/20)
A 4.10	Developing sugarcane based Integrated Farming System Models for small farm holders of sub-tropical India (A.K. Singh, T.K. Srivastava, A.K. Sharma, Anil K. Singh, Akhilesh Kumar Singh, A.K. Sharma, Rakesh Kumar Singh and M.M. Roy; 09/15-LT)
AICRP on Sugarcane trials	
A S 68	Impact of integrated application of organics and inorganics in improving soil health and sugarcane productivity (A.K. Singh, K.P. Singh, T.K. Srivastava and S.R. Singh; 2014-2018)
AS 69	Use of plant growth regulators (PGRs) for enhanced yield and quality of sugarcane (R.R. Verma and S.R. Singh; 2015-2018)
AS 70	Scheduling irrigation with mulch under different sugarcane planting method (C. Gupta, S.K. Shukla, V.P. Jaiswal and V.K. Singh; 2016-2019)
AS 71	Carbon sequestration assessment in sugarcane based cropping system (V.P. Jaiswal, S.K. Shukla, V.P. Singh; 2016-2019)
AS 72 (A)	Agronomic performance of elite sugarcane genotype (Early) (V.P. Singh and S.K. Shukla: 2016-LT)
AS 72 (B)	Agronomic performance of elite sugarcane genotype (Midlate) (K.K. Singh and V.P. Singh; 2016-LT)
AICRP on Soil Test Crop Response Correlation	
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)
III. 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 the Division)
Plant Pathology	
M 5.10	Management of yellow leaf disease (YLD) of sugarcane through thermotherapy (Dinesh Singh and S.K. Holkar, 05/15-04/18)
M 17	Evaluation/screening of sugarcane germplasm/genotypes against red rot and smut (M.R. Singh, Dinesh Singh and S.K. Duttamajumder, 1992-93-LT)
M 15.6	Enhancing efficacy of *Trichoderma* based red rot management system (Deeksha Joshi and Pushpa Singh, 04/12-03/18)

AICRP on Sugarcane trials	
Plant Pathology	
PP 14	Identification of pathotypes in red rot pathogen (Dinesh Singh, S.K. Duttamajumder and M.R. Singh)
PP 17	Evaluation of zonal varieties against red rot, smut and wilt (Dinesh Singh, S.K. Duttamajumder and M.R. Singh)
PP 22	Survey of sugarcane diseases naturally occurring in the area on important varieties (Dinesh Singh, S.K. Duttamajumder and M.R. Singh)
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	Standardisation 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)
IV. Division of Plant Physiology and Biochemistry	
PB 27	Molecular study to reveal transcriptomes and genes associated with sucrose transport and accumulation in sugarcane (A. Chandra and Radha Jain; 04/12-03/18)
PB 28	Minimizing post-harvest sucrose deterioration and its molecular assessment in sugarcane sugarcane (A. Chandra and Radha Jain; 04/12-03/18)
PB-Inter-Institutional	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 and M Ramadurai; 2013-2018)
V. Division of Agricultural Engineering	
AE 1.22E	Development of modified furrower type sugarcane planter (A.K. Singh and R.D. Singh; 03/15 - 03/18)
AE 1.52	Development and evaluation of tractor operated multipurpose tool frame with attachments for sugarcane (Sukhbir Singh and A.K. Singh, 10/15 - 09/18)
AE 1.19B	Development of two row disc type ratoon management device with and without stubble shaving attachments ((A.K. Singh and Sukhbir Singh; 09/16 - 08/19)
AE 1.23	Development of cane node planter (A.K. Singh; 09/16 -08/19)
AE 6.8	Sustaining sugarcane yield under multiple ratooning through drip irrigation (Rajendra Gupta; 03/16 - 03/19)
AE 7.6.1	Development of integrated drying system for jaggery drying (R.D. Singh, A.K. Singh, S.I. Anwar and D. Kumar;11/16-11/19)
AE 7.6.2	Development of a jaggery furnace with efficiency boosting device (S.I. Anwar, 04/12-03/18)
AE 7.1.1	Refinement of sugarcane cleaner cum washer for jaggery (S.I. Anwar, Dilip Kumar and R.D. Singh; 11/16-11/18)
AICRP on Farm Implements and Machinery trials	
FIM/IISR/PMW/86	Manufacturing of prototypes for conducting field adoptability trials under varying agro-climatic and soil conditions (A.K. Singh, 04/86 - LT)

FIM/IISR/PFT/2015/01	Prototype feasibility trial of Pant-ICAR sub-soiler-cum-differential rate fertilizer applicator (R.D. Singh, Sukhbir Singh and A.K. Singh; 04/16 - 03/18)
FIM/IISR/PFT/2015/02	Prototype feasibility trial of tractor mounted reaper binder (Sukhbir Singh, R.D. Singh and A.K. Singh; 04/16 - 03/18)
FIM/IISR/FLD/2017/01	IISR tractor operated disc type ratoon management device (A.K. Singh, Sukhbir Singh and A.K. Sah, 04/17 - 03/20)
FIM/IISR/FLD/2017/02	IISR tractor operated deep furrow sugarcane cutter planter (A.K. Singh, Sukhbir Singh and R.D. Singh; 04/17 - 03/20)
FIM/IISR/FLD/2017/03	IISR tractor operated sugarcane trench planter (A.K. Singh, Sukhbir Singh and R. Gupta; 04/17 - 03/20)
FIM/IISR/FLD/2017/04	IISR tractor operated deep furrow sugarcane cutter planter/trench planter –cum-multicrop raised bed seeder (A.K. Singh and Sukhbir Singh; 04/17 - 03/20)
AICRP on Post Harvest Engineering Technology trials	
LKO/PHTS/14/02	Development of a semi-automatic jaggery manufacturing plant (Dilip Kumar, S.I. Anwar, G.S. Nevkar and PVKJ Rao; 04/14 - 12/17)
LKO/PHTS/16/01	Development of sugarcane juice extractor for household use (Dilip Kumar and S.I. Anwar; 01/16 - 12/18)
LKO/PHTS/16/02	Development of jaggery gems using liquid nitrogen (Dilip Kumar and S.I. Anwar; 01/16 - 12/18)
LKO/PHTS/13/02	Study on determining storage losses in food grains in FCI and CWC warehouses and to recommend norms for storage losses in efficient warehouse (Dilip Kumar and S.I. Anwar; 01/13 - 12/17)
VI. Extension and Training Unit	
ET 1.12	Documentation and confirmation of indigenous technical knowledge under sugarcane based cropping systems (Kamta Prasad, T.K. Srivastava, K.P. Singh, Rajendra Gupta and A.K. Sah; 1/12-12/18)
ET 1.14	Entrepreneurship development for sugarcane seed production and multiplication (A.K. Sah, S.N. Singh, Sanjeev Kumar, S.N. Sushil and Kamta Prasad, 10/12 – 10/19)
ET 1.15	An analysis of gender perspective in sugarcane cultivation (Kamta Prasad, R.S. Dohare, A.K. Sah, Rajesh Kumar and A.K. Sharma; 01/17-12/19)
VII. Agriculture Knowledge Management Unit	
AES 4.15	Development of data mining and presentation tools in sugarcane (S.S. Hasan, Rajesh Kumar and L.S. Gangwar; 04/12-03/18)
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, S.K. Duttamajumder, A.D. Pathak and M.R. Singh, 04/15 – 03/20)
AES 4.18	Estimation of techno-economic feasibility of sugarbeet cultivation for sugar and ethanol production in India (A.K. Sharma, T.K. Srivastava and A.D.Pathak; 10/15 -09/17)
AES 4.19	Online database and mixed model analysis of sugarcane varieties tested/released in India (Rajesh Kumar, S.S. Hasan, A.D. Pathak and V.K. Gupta, 9/17-12/18)
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, 10/16-09/19)

Externally funded	
DBT	RNA seq for SNP mining and linkage mapping in sugarcane (Nandita Banerji, Sanjeev Kumar, RK Singh; 11/14-05/18)
DBT	Accredited Test Laboratory (ATL) under National Certification System for Tissue Culture Raised Plants (NCS-TCP) (Coordinator: Sanjeev Kumar, PIs: Sanjeev Kumar and S.K. Holkar; 03/15-03/20)
PPV&FRA	Central Sector Scheme for PPV&FRA (J. Singh, P.K. Singh (2006-LT)
ICAR	ICAR seed project "Seed production in agricultural crops" (Sanjeev Kumar, P.K. Singh, 2017-2020)
UPCAR	Evaluation of microbial mapping and their corelation on productivity, plant and soil health in major cropping systems of Uttar Pradesh (S.R. Singh, 2014-17)
CST, UP	Enhancing sugarcane bio-productivity: Physiological and molecular interventions using nutrient-hormone carriers
UPCAR	Centre of Excellence in Farm Machinery (Sukhbir Singh, A.K. Singh and R.K. Singh; 05/17 - 05/22)
ICAR	Agri-consortia research platform on water (Rajendra Gupta, T.K. Srivastava, Rama Kant Rai, J. Singh, Pushpa Singh, S.R. Singh, R.R. Verma and S.N. Singh; 12/15-03/19)

Contract research
Bio-efficacy evaluation of tembotrione 420 SC (Laudis 420 SC) in sugarcane (V.P. Singh, K.K. Singh, S.N. Singh and S.K.Shukla; 2016 – 2018)
Bio-efficacy and phytotoxicity evaluation of RJKP 1505 (2,4-D Sodium Salt 67.7% + Metribuzin 16.5% WP) in sugarcane (V.P. Singh, K.K. Singh; A.K. Singh and S.K. Shukla; 3/16- 8/18)
Field bio-efficacy and phyto-toxicity evaluation of 'Flumioxazin 50% SC' against weeds in sugarcane and its effect on succeeding crop (V.P. Singh, K.K. Singh, V.P. Jaiswal and S.K. Shukla; 10/16-8/19)
Field bio-efficacy and phytotoxicity evaluation of atrazine 50% WP against weed complex in sugarcane (K.K. Singh, V.P. Singh and S.K. Shukla; 10/16-7/17)
Field bio-efficacy and phytotoxicity evaluation of ametryn 80% WG against weed complex in sugarcane (K.K. Singh, V.P. Singh, V.P. Jaiswal; 10/16-07/18)
Evaluation of Atrazine 50% WP against weeds in sugarcane (V.K. Singh, V.P. Singh and Dinesh Singh; 10/16-7/17)
Bio-efficacy evaluation of SL 160 10% herbicide against weed control of sugarcane (A.P. Dwivedi, V.K.Singh and K.K. Singh; 3/17 -9/19)
Bioefficacy evaluation of Ametryn 80% WDG herbicide against weed complex of sugarcane (V.P.Singh, V.K.Singh, K.K.Singh and A.P.Dwivedi; 3/17 - 9/19)
Bioefficacy and phytotoxicity evaluation of halosulfuron-methyl 75% WG against weeds in spring planted sugarcane (V.P. Singh, K.K. Singh, V.K. Singh and A.P. Dwivedi; 2017-2018)
Evaluation of PII 8007 against termites and cane borers of sugarcane and its effect on bio-agents and crop (M.R. Singh and Arun Baitha; 05/17-04/19)

CHAPTER 17

Review, Monitoring and Evaluation

RAC Meeting

XXIII meeting of Research Advisory Committee of the ICAR-IISR, Lucknow was held on July 21-22, 2017 under the chairmanship of Dr Y.S. Nerkar, former Vice-Chancellor, MPAU, Rahuri. Dr. S.R. Maloo, Ex. Director Research, MPUAT, Udaipur; Dr. S. Sithanantham, Director, Sun Agro Biotech Research Centre, Chennai; Dr. Surendra Singh, Ex. Project Coordinator (FIM); Dr. Rajvir Singh, Ex. Member CACP, Govt. of India; Dr. Anoop Kumar, General Manager (Cane), Biswan Sugar Mill, Sitapur; Farmers representatives *viz.*, Sh. Shiv Kumar Rana, Meerut and Sh. Shivendra Mohan Dubey, Kanpur Dehat besides; Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow; Dr. A.K. Sharma, Pr. Scientist (Ag. Econ), ICAR-IISR, as Member Secretary, Project Coordinator (Sugarcane), Heads of the Divisions and Scientists from ICAR-IISR were also present.

Dr. A.D. Pathak, Director, IISR made a presentation on sugarcane scenario in India. Dr. L.S. Gangwar, Principal Scientist and I/c PME Cell, Dr. D.R. Malaviya, Head, Division of Crop Improvement; Dr. V.P. Singh, Head, Division of Crop Production; Dr. M.R. Singh, Head, Division of Crop Protection; Dr. Radha Jain, Head, Division of Plant Physiology and Biochemistry; Dr. A.K. Singh, Head, Division of Agricultural Engineering; Dr. A.K. Mall, Senior Scientist & In-charge IISR Regional Centre, Motipur (Bihar); Dr. S.N. Singh, Pr. Scientist & Incharge, KVK, Lucknow and nodal officer, IISR, Biological Control Centre, Pravaranagar; Dr. A.K. Sah, Principal Scientist & Incharge, Training & Extension Unit; Dr. Rajesh Kumar, Principal Scientist & Incharge, AKMU and Dr. A.K. Sharma, Member Secretary, RAC, presented the research highlights of respective Divisions/Sections/ Centres. The RAC appreciated the efforts of the scientists and made following major recommendations:

- Spread of new varieties be hastened by production of high quality seed at three stages in sufficient quantities. Seed production at the later two stages may be done on selected farmers' fields in association with the sugar mills. Micro-propagation technique should be resorted for fast initial multiplication.
- With the objective of reducing the expenses on synthetic fertilizers, a field trial should be conducted using *Glucanacetobactor diazotrophicus*, PhosphateSB, PotashSB, etc. efficient microbes and levels of RDF. Microbiologist should be associated with the experiment.
- Survey and surveillance of pests may be supplemented with a pheromone trap based monitoring network initiative with the assistance of the personnel of sugar mills and KVK's. For eco-friendly management of the sugarcane borers, pheromone trapping as a tool should be evaluated. One day training of the sugar mill and KVK personnel may be arranged for this purpose. A live repository of the hardy strains (native strains of *Trichogramma)* for sub-tropical India may be maintained.
- Two field experiments should be conducted; one on combining the periodic foliar sprays of different growth regulators like GA_3, IBA, 6BA and NAA in addition to the recommended fertilizers; and another to test the role of Silica (by soil application and foliar sprays) in relation to productivity and tolerance to moisture stress, pests and diseases. Inter-disciplinary team involving a plant physiologist, soil scientist, entomologist and plant pathologist should be associated.

- The latest version of the tractor operated ratoon management attachment developed at the Institute be popularized by demonstrating on farmers' fields in association with the sugar mills. Manufacturers should be contacted for the production of the trench planter on large scale.
- Demonstrations should be arranged on farmers' fields to demonstrate the substantial gain obtained in cane productivity by GA_3 treatment. Also in association with the Plant Breeding group, the sugar mills should be advised to go for proper varietal planning in the cane planting in their respective areas to ensure cane supply for a longer crushing period with sustained high sugar recovery.
- Periodical sugarcane, sugar and by-products production scenario should be analysed and economic intelligence be provided to all the stakeholders including the farmers, government and the industry.

IRC Meeting

The Institute Research Council (IRC) meeting was held under the Chairmanship of Dr. A.D. Pathak, Director during August 8-14, 2017. In the meeting, all the scientists and four technical officers of the Institute participated and discussed the research findings of ongoing-Institute research projects and the technical programme for the next year (2017-18) was finalized.

IMC Meetings

Forty third meeting of Institute Management Committee (IMC) was held under the chairmanship of Dr. A.D. Pathak on December 15, 2017. Progress of R & D efforts was reviewed and various administrative matters were discussed in the meeting. Forty fourth meeting of IMC was held on March 21, 2018

Institute Biosafety Committee Meeting

The Institute Biosafety Committee (IBSC) Meeting was held on December 29, 2017 under the Chairmanship of Dr. A.D. Pathak. The meeting was attended by Dr. Anil Kumar (DBT nominee), Dr. Manish Mishra (external expert), internal experts, Dr. Sangeeta Srivastava, Dr. M. Swapna, and Dr. Sanjeev Kumar (Member Secretary). Various steps taken by different laboratories of the Institute in the area of biosafety were discussed.

Scientific Advisory Committee Meeting of KVK

Scientific Advisory Committee Meeting of KVK, ICAR-IISR, Lucknow was organized at ICAR-IISR, Lucknow under the chairmanship of Dr. A.D. Pathak on June 3, 2017. The Chief Guest of the meeting, Dr. S. Solomon, VC, CSAUA&T, Kanpur stressed the

need for streamlining of KVK activities in the interest of farmers and enhancing their income. Dr. Pathak emphasized that in the light of increasing urbanization in Lucknow district, the need to initiate roof top kitchen gardening and peri-urban agriculture besides other developmental activities related to agriculture. Dr. S.N. Singh, Principal Scientist & Incharge, KVK highlighted the achievements and future line of action. Dr. R.K. Singh organized the programme, while Dr. Deepak Rai presented the achievements of KVK for 2016-17.

CHAPTER 18

Participation in Conferences/Seminars/Symposia/Workshops/ Meetings

Name	Conference/Seminar/Symposia	Venue	Date
Dr. A.K. Sharma and Sh. Brahm Prakash	National Seminar on Growth and Social Sector Development in Uttar Pradesh Economy	University of Lucknow, Lucknow	April 6-7, 2017
Drs. S.K. Shukla, S.N. Sushil and Ram Ratan Verma	National Seminar on "Integrated Approach for Enhancing Farm Productivity by Adopting Improved Cultivation and Analytical Practices"	NSI, Kanpur	April 07, 2017
Dr. A.D. Pathak	Meeting on Breeder Seed Production Programme in Bihar	Patna	April 11, 2017
Dr. S.N. Singh and all the SMSs of KVK, Lucknow	Meeting with Head and other Scientists of KVK, Raebareli	KVK, ICAR-IISR, Lucknow	April 25, 2017
Sh. Brahm Prakash and Sh. Atul Kumar Sachan	Seminar on Innovation-Improving Lives	Council of Science & Technology, Uttar Pradesh, Lucknow	April 27, 2017
Dr. A.D. Pathak	ICAR Review Committee Meeting of Crop Sciences	ICAR-IARI, New Delhi	April 28, 2017
Dr. S.N. Singh	Meeting to discuss redistribution of new 22 KVKs of Uttar Pradesh	KVK, ICAR-IISR, Lucknow	May 1, 2017
Dr. Sukhbir Singh	Meeting on "Assessment of Farm Mechanization Status in India"	ICAR-CIAE, Bhopal	May 2, 2017
Drs. S.N. Singh, V.K. Singh and R.K. Singh	Meeting with District Magistrate, Lakhimpur Kheri for arranging the land for establishment of new KVK	D.M. Office, Lakhimpur Kheri	May 9, 2017
All Scientists, Dr. Om Prakash and Sh. Brahm Prakash	Annual Convention (2017) and Technical Expo of North Indian Sugarcane & Sugar Technologists Association	ICAR-IISR, Lucknow	May 12-13, 2017
Dr. S.K. Shukla	23rd SLSC Meeting of RKVY	Mumbai	May 25, 2017
All Scientists, Technical and Administrative Personnel of the Institute	*Swachchhta* Workshop on Waste Management	ICAR-IISR, Lucknow	May 26, 2017
Drs. A.D. Pathak, S.N. Singh and all the SMSs of KVK, Lucknow	Scientific Advisory Committee Meeting of KVK, ICAR-IISR, Lucknow	ICAR-IISR, Lucknow	June 3, 2017
Drs. A.D. Pathak and S.N. Singh	Zonal Workshop of KVKs of Uttar Pradesh and Uttarakhand	ICAR-ATARI, Kanpur	June 8-10, 2017
Drs. A.D. Pathak, A.K. Singh and S.N. Singh	Brainstorming Meeting on "Enhancing Productivity and Recovery in Sugarcane through Vertical Improvement, Water Management and Farm Mechanization	Harinagar Sugar Mill, Harinagar (Bihar)	June 15, 2017
Dr. A.K. Mall	International Seminar on Agriculture, Horticulture and Plant Science	Rishikesh	June 24-25, 2017

Dr. A.D. Pathak	240th Meeting of the Governing Body of the ICAR Society	NASC Complex, New Delhi	June 28, 2017
Dr. A.D. Pathak	Workshop on "Challenges and Opportunities in Sugarcane Cultivation under Changing Climate Scenario"	ICAR-NIASM, Baramati	July 10-11, 2017
Dr. A.D. Pathak	Directors Conference	NASC Complex, New Delhi	July 15, 2017
Dr. A.D. Pathak	241st Meeting of the Governing Body of the ICAR Society	NASC Complex, New Delhi	July 20, 2017
Dr. A.D. Pathak, all Scientists of the Institute, Sh. Brahm Prakash and Sh. Atul Kumar Sachan	23rd meeting of Research Advisory Committee	ICAR-IISR, Lucknow	July 21-22, 2017
Drs. J. Singh, D.K. Pandey, P.K. Singh and Sanjeev Kumar	XII Annual Review Meeting of ICAR Seed Project	MPKV, Rahuri	July 29-30, 2017
Dr. Dilip Kumar	ICAR-IFAD Workshop	NASC Complex, New Delhi	August 3, 2017
Drs. Rajesh Kumar and A.K. Singh	75th Annual Convention and International Sugar Expo	Hotel Le Meridien, Kochi	August 3-5, 2017
Dr. A.D. Pathak	Meeting of Eastern Region	Motihari	August 5, 2017
Dr. A.D. Pathak, all Scientists of the Institute, Sh. Brahm Prakash and Sh. Atul Kumar Sachan	Meeting of Institute Research Council	ICAR-IISR, Lucknow	August 8-14, 2017
Sh. Abhishek Kumar Singh	Effective implementation of *Rajbhasha* policy for increasing administrative/ managerial efficiency in ICAR Institutes	ICAR-IIHR, Bengaluru	August 8-16, 2017
Drs. A.D. Pathak and S.K. Shukla	Meeting of State Specific Action Plan on Water	National Water Mission, Ministry of Water Resources	August 10, 2017
Dr. A.K. Sah	Technical Conference	Jodhpur	August 17-18, 2017
Dr. S.K. Shukla	Review meeting of the Vigilance Officers, Heads of Administrative/ Finance Wing	ICAR-CIAE, Bhopal	August 18, 2017
Drs. A.D. Pathak, S.N. Singh and all SMSs of KVK, Lucknow	*Sankalp Se Siddhi* Programme	Gungwachh (Amethi)	August 25, 2017
Dr. A.D. Pathak, all Scientists and Technical Officers	*Sankalp Se Siddhi* Programme	ICAR-IISR, Lucknow	August 29, 2017
Drs. Rajesh Kumar and A.K. Singh	National Conference on 100 Years of Sweet Revolution in India	NASC Complex, New Delhi	August 29, 2017
Sh. Brahm Prakash and Sh. Mohd. Ashfaque	National Symposium on IPRs in Agricultural Research	BBAU, Lucknow	August 30-31, 2017
Drs. A.K. Singh and R.D. Singh	National Workshop on "Reshaping Agricultural Research Education and extension Systems Management for 2030"	ICAR-NAARM, Hyderabad	August 31-September 1, 2017
Drs. A.D. Pathak, S.K. Shukla, A.K. Singh and A.K. Singh	Workshop on 'Intercropping in Sugarcane"	ICAR-IISR RC, Motipur (Bihar)	September 10, 2017

Dr. Amaresh Chandra	Foundation day celebration of Indian Society of Agricultural Biochemists & Agri Biochem Conclave	CSAUA&T, Kanpur	September 10, 2017
Drs. A.D. Pathak, A.K. Singh, P.K. Singh, Sukhbir Singh, L.S. Gangwar, S.N. Singh, Ram Ratan Verma, D.K. Panday, Amaresh Chandra, Deeksha Joshi, V.P. Jaiswal, Chandra Gupta, Rajesh Kumar, S.N. Sushil, Lalan Sharma, Rajendra Gupta	International Symposium on Sugarcane Research since Co 205: 100 Years and Beyond (SucroSym 2017)	TNAU & ICAR-SBI, Coimbatore (T.N.)	September 18-21, 2017
Dr. A.D. Pathak and Sh. Brahm Prakash	Sugar Tech 2017	Hotel Taj Vivanta, Lucknow	September 20, 2017
Drs. A.D. Pathak, S.K. Shukla,, M.R. Singh, Amaresh Chandra, V.P. Jaiswal, A.K. Singh, A.K. Singh, S.R. Singh, T.K. Srivastava, V.P. Singh, P.K. Singh, J. Singh, S.N. Singh, C. Gupta, Rajendra Gupta, D.K. Pandey, Lalan Sharma, Dinesh Singh, Ram Ratan Verma, S.K. Awasthi, Adil Zubair, Avadhesh Kumar Yadav	Group Meeting of AICRP on Sugarcane	TNAU, Coimbatore	September 22-23, 2017
Dr. S.K. Shukla	Varietal Identification Committee Meeting	TNAU, Coimbatore	September 23, 2017
Drs. A.D. Pathak, L.S. Gangwar, S.I. Anwar, A.K. Sah, A.K.Dwivedi, Om Prakash, Brahm Prakash and Abhishek Kumar Singh	*Antarrashtriya Vaigyanik Sangoshthi* on *Paryavaran Pradooshan : Chunautiyan Evam Rannitiyan*	CSIR-Indian Institute of Toxicology Research, Lucknow	October 11-13, 2017
Drs. A.D. Pathak, L.S. Gangwar, A.K. Sah, Om Prakash, Brahm Prakash	National Seminar on "Farmer Centric Cinema"	ICAR-IISR, Lucknow	October 14-16, 2017
Drs. A.D. Pathak, J. Singh, V.K. Singh, L.S. Gangwar, Brahm Prakash, Om Prakash, A.K. Sachan, A.K. Singh, Abhishek Kumar Singh	RASSA National Convention cum Seminar on Doubling Farmers' Income and Farm Profitability by 2022	BBAU, Lucknow	October 28-29, 2017
Dr. A.D. Pathak	Inter-Session Meeting of the Consultative Committee of the Ministry of Agriculture & Farmers Welfare	Parliament House, New Delhi	November 2, 2017
Dr. Sukhbir Singh	QRT Meeting of AICRP on FIM	PAU. Ludhiana	November 6-8, 2017
Drs. A.K. Sharma and L.S. Gangwar	25th Annual Conference of Agricultural Economics Research Association (India)	ICAR-NAARM, Hyderabad	November 7-9, 2017
Dr. Y.P. Singh	National Seminar on Potential, Prospects and Strategies for Doubling Farmers Income: Multi-Stakeholder Convergence	College of Veterinary Science, Assam Agriculture University, Guwahati	November 9-11, 2017

Drs. L.S. Gangwar and A.K. Sah	NIAP Workshop on Research Impact Assessment	ICAR-NIAP, New Delhi	November 13, 2017
Dr. Amaresh Chandra	IBSC Meeting as DBT nominee	ICAR-IIPR, Kanpur	November 14, 2017
Dr. Pushpa Singh	Conference on "Ethanol as Transport Fuel"	CIRT, Pune	November 24, 2017
Drs. Sangeeta Srivastava and M. Swapna	International Seminar on "Advancements in Biotechnology : Current and Future Perspectives ISABCFP-2017	Integral University, Lucknow	November 25, 2017
Dr. Rajesh Kumar	71st Annual Conference of Indian Society of Agricultural Statistics	ICAR- Directorate of Rapeseed - Mustard Research, Bharatpur	November 25-27, 2017
Dr. S.K. Shukla	Meeting on 3rd Edition of Industry Water Conclave	New Delhi	November 28, 2017
Dr. A.K. Sah	ISEE National Seminar	BAU, Sabour, Bhagalpur	November 28-30, 2017
Dr. A.D. Pathak	242nd Meeting of the Governing Body of the ICAR Society	NASC Complex, New Delhi	November 29, 2017
Dr. Sangeeta Srivastava	International Seminar on "Impact of Environment on Womens' Health"	Integral University, Lucknow	November29-December 1, 2017
All Scientists of ICAR-IISR	National Seminar on Healthy Soil for Healthy Life	ICAR-IISR, Lucknow	December 5, 2017
Dr. S.N. Singh	Farmers' Seminar – cum- Farmers' fair	Lakhimpur Kheri	December 6, 2017
Dr. Amaresh Chandra	Seminar on Rural Technology	UPCST, Lucknow	December 8, 2017
Dr. S.K. Shukla	National Seminar on Organic Farming for Sustainable Agriculture and Livelihood Security under Changing Climatic Conditions	CSAUA&T, Kanpur	December 12, 2017
Dr. Dilip Kumar	QRT Meeting of PHET	PAU, Ludhiana	December 12-14, 2017
Dr. Amaresh Chandra	Institute Management Meeting	ICAR-CISH, Lucknow	December 20, 2017
Dr. A.K. Singh	XXXII Annual Workshop of AICRP on FIM	UAS, Raichur	December 20-22, 2017
Dr. A.K. Sah	CARD-IFPRI Workshop on Agri-business : Challenges and opportunities	Hotel Gomti, Lucknow	December 21, 2017
Dr. A.D. Pathak	Meeting for finalizing the documents of doubling farmers income	ICAR-IVRI, Izatnagar, Bareilly	January 2, 2018
Dr. L.S. Gangwar	High level committee meeting for draft preparation of approach paper on doubling farmers' income	ICAR—IVRI, Bareilly	January 2-5, 2018
Drs. R.D. Singh, Sukhbir Singh and S.I. Anwar	52nd Annual Convention & Symposium of Indian Society of Agricultural Engineering	Anand Agriculture University, Anand	January 8-10, 2018

Dr. S.K. Shukla	79th Meeting of Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops	ICAR-IARI, New Delhi	January 20, 2018
Dr. Dilip Kumar	XXXIII Annual Workshop on PHET	JAU, Junagadh	January 20-21, 2018
Dr. Rajesh Kumar	Policy Workshop on Big Data Analytics in Agriculture	ICAR-NAARM, Hyderabad	February 8-9, 2018
Dr. S.N. Sushil	International Conference on "Applied Zoological Research for Sutainable Agriculture and Food Security"	BHU, Varanasi	February 9-11, 2018
Drs. A.D. Pathak, S.K. Shukla, Amaresh Chandra, A.K. Singh, L.S. Gangwar, S.N. Sushil, R.D. Singh, M. Swapna, A.K. Sah, S.I. Anwar, V.P. Jaiswal, Deeksha Joshi, Lalan Sharma, Brahm Prakash & Om Prakash	International Conference on Sustainability of Smallholder Agriculture in Developing Countries under Changing Climate Scenario	CSAUA & T, Kanpur	February 14-17, 2018
Dr. A.D. Pathak	243rd Meeting of the Governing Body of the ICAR Society	NASC Complex, New Delhi	February 20, 2018
Dr. A.D. Pathak	All India Agri Startups Convention 2018	New Delhi	February 21, 2018
Dr. A.K. Singh	Brain Storming Interaction Meet on "Engineering Interventions for Production and Processing of Different Crops"	ICAR-CIAE, Bhopal	February 26-27, 2018
Dr. A.D. Pathak	89th Annual General Meeting of the ICAR Society	NASC Complex, New Delhi	February 28, 2018
Dr. S.N. Singh	Farmers' Seminar – cum- Farmers' Fair	Banda	March 3, 2018
Drs. S.N. Sushil and M. Swapna	6th IAPSIT International Sugar Conference IS-2018 on "Sugar Crops Improvement, Biotechnology, Bio Refinery and Diversification : Impacts on Bio-based Economy"	Udon Thani, Thailand	March 6-9, 2018
Dr. Y.P. Singh	Executive Committee Meeting of the Society for Community Mobilization and Sustainable Development	ICAR-IARI, New Delhi	March 7-8, 2018.
Dr. Sangeeta Srivastava	National Conference on "Technological Empowerment of Women"	Vigyan Bhawan, New Delhi	March 8-9, 2018
Drs. L.S. Gangwar & S.I. Anwar	National Conference on Promoting Entrepreneurial Growth through Innovative Approaches in Food Processing Sector	ICAR-CIPHET, Ludhiana	March 16-17, 2018
Dr. A.D. Pathak	National KVK Conference for the year 2018	ICAR-IARI, New Delhi	March 16-17, 2018
Dr. A.D. Pathak	51st Meeting of Advisory Board of National Sugar Institute, Kanpur	Krishi Bhawan, New Delhi	March 20, 2018
Dr. A.D. Pathak	Meeting with the Special Secretary, DARE and Secretary, ICAR	New Delhi	March 28, 2018

CHAPTER 19

Events Organized

Annual Convention and Technical Expo-2017 of NISSTA jointly organized

A two-day Annual Convention and Technical Expo-2017 of North Indian Sugarcane & Sugar Technologists' Association was jointly organized by NISSTA and ICAR-IISR at ICAR-IISR, Lucknow on May 12-13, 2017. Addressing as the Chief Guest, Dr. S. Solomon, VC, CSAUA&T, Kanpur congratulated all the stakeholders in making Uttar Pradesh the largest sugar producing state of the country by producing 8.77 million tonnes of sugar during 2016-17. Speaking as the Guest of Honour, Dr. Bakshi Ram, Director, ICAR-SBI, Coimbatore thanked the organizers for appreciating his efforts of developing a sugarcane variety Co 0238 which has become instrumental in making U.P. the top sugar producing state of the country.

Dr. G.S.C. Rao, Managing Director, Global Canesugar Services Pvt. Ltd stressed on the need of agro-processing for agricultural development. Dr. R.L. Tamak, Chief Executive Director (Sugar), DSCL Group, New Delhi stressed on four ways to double the income of farmers *viz*., increase in productivity, reduction in cost of cultivation, other allied activities and efficient marketing.

National Seminar on Agriculture Research and Education organized

One day National Seminar on Agriculture Research and Education in Relation to Development of Integrated Agriculture: Challenges & Solutions was jointly organized by UPCAR, ICAR-IISR, Lucknow and UPAAS at IISR, Lucknow on June 14, 2017.

Sh. Ram Naik, the Hon'ble Governor of Uttar Pradesh urged the Scientists to take the improved farm technologies to the farmers' fields. He highlighted that the scientists in collaboration with State machinery could play an instrumental role in increasing the farm production of the State. Sh. Surya Pratap Shahi, the Hon'ble Minister of Agriculture, Govt. of Uttar Pradesh expressed his satisfaction over the record production of wheat, paddy, pulses, potato and sugar in Uttar Pradesh. He urged the scientists to help in reducing the cost of cultivation and post harvest losses. In the technical session, Prof. R.B. Singh, Ex. Chairman, ASRB, New Delhi delivered a talk on "Agriculture Research & Education for Development". Dr. Mangala Rai, Ex. Secretary, DARE & DG, ICAR gave a presentation on "Agriculture in the waiting-should it wait any more". Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow highlighted the role of IISR in the emergence of Uttar Pradesh State as the largest sugar producing state in India by contributing 8.77 million tonnes of sugar. Many distinguished scientists were awarded by the UPAAS under different categories.

Cane Development Minister, Uttar Pradesh chaired a meeting of Sugarcane Researchers

A meeting of scientists from ICAR-IISR, Lucknow; UPCSR, Shahjahanpur and its different centres along with officials from State sugarcane Department was held on April 12, 2017 under the Chairmanship of Shri Suresh Rana, the Hon'ble Minister of Cane Development and Sugar Industry, Govt. of Uttar Pradesh. He emphasized that the research findings should be made simple and be communicated in local language to the farmers.

National Seminar on Farmer Centric Cinema organized

Three days National Seminar on Farmer Centric Cinema, jointly organized by Samagra Vikas Welfare Society and ICAR-IISR, Lucknow on October 14-16, 2017. The Seminar was inaugurated by Dr. Om Prakash, Former Principal Secretary (Tourism) and Sugarcane Commissioner, Govt. of U.P.

Sankalp Se Siddhi programme organized

In view of fulfilling dream of the Hon'ble Prime Minister of India for doubling the farmers income by the year 2022 by adopting seven point programme on agriculture and allied sector, a programme on "*Sankalp Se Siddhi*" was conducted by KVK, IISR on August 29, 2017 in which the Chief Guest, Shri Kaushal Kishore, Hon'ble Member of Parliament, Mohanlalganj took an oath of doubling the farmers' income by the year 2022. Sh. Devendra Chaudhary, Secretary, Animal Husbandry, Dairy and Fisheries, Ministry of Agriculture and Farmers Welfare, Govt. of India urged the farmers to implement 100% artificial insemination, *in-vitro* fertilization, embryo transplantation and balanced feeding for animals.

The "*Sankalp Se Siddhi*" programme was also organized at ICAR-IISR Regional Centre, Motipur (Bihar) on September 10, 2017.

67th Foundation Day celebrated

The Institute celebrated its 67th Foundation Day on February 16, 2018 which marked the successful journey of 66 glorious years of service to the Nation since the establishment of the Institute in 1952. Speaking on the occasion, Dr. R.K. Singh, ADG (Commercial Crops), ICAR informed that area, production and productivity of sugarcane and sugar recovery in India have increased by 2.55, 4.06. 1.82 and 1.11 times, respectively during the last 66 years. Now, India has become self reliant in sugar production by producing 28 million tonnes of sugar.

Dr. A.D. Pathak, Director, ICAR-IISR delivered the welcome address and highlighted the achievements made during the last year. Dr. Pathak reiterated the commitment of IISR to address the emerging challenges in sugarcane and sugar sector.

Swachchhta Workshop on Waste Management

The Institute organized *Swachchhta* Workshop on Waste Management on May 26, 2017. Dr. P.S. Ojha, State Coordinator/Member Convener of U.P. State Bio-energy Development Board delivered an elaborated lecture on "Bio-Energy and Climate Resilient Agriculture Based Sustainable Development". He underlined the efforts of U.P. State Bio energy Development Board in bringing up the change through intervention of various technologies based on holistic approach of waste utilization.

World Soil Day observed at IISR

A National Seminar on "Healthy Soil for Healthy Life" was organized at ICAR-IISR, Lucknow in association with Indian Society of Soil Science, Lucknow Chapter on December 5, 2017 on the occasion of World Soil Day.

Agricultural Education Day celebrated

Agricultural Education Day was celebrated on December 3, 2017. On this occasion, Dr. A.D. Pathak, Director, ICAR-IISR addressed the UG/PG students, Ph.D. scholars, SRF, JRF and Young Professionals working in the Institute. Dr. Pathak encouraged the students to be more focused and open for the innovative ideas and also added that young people are torchbearer of the future.

Vigilance Awareness Week observed

Vigilance Awareness Week was observed at the Institute during October 30 - November 4, 2017. On this occasion, the Director, ICAR-IISR administered the oath to the employees for not taking and giving bribe and to report such matters to the concerned agencies.

National Science Day observed

National Science Day was observed at the Institute on February 28, 2018 with a great fervour. All the staff of the Institute was present on this occasion and young researchers participated in the programme with great enthusiasm.

World IP Day observed

World IP Day was observed on April 26, 2017

at IISR. On this occasion, Dr. A.D. Pathak, Director, emphasized the need of keeping the rights of intellectual property to the Scientists of the Institute before commercializing the technology.

Republic Day celebrated

Republic day was celebrated with great fervour and enthusiasm. The national flag was hoisted by Dr. A.D. Pathak, Director of the Institute. Speaking on the occasion, Dr. Pathak recalled the significance of the day and contributions of freedom fighters for the country.

Independence Day celebrated

Independence day was celebrated at the Institute on August 15, 2017 with great fervour and enthusiasm. The National Flag was hoisted by Dr. A.D. Pathak, The Director of ICAR-IISR, Lucknow. In his speech, Dr. Pathak emphasized the need to take inspiration on this eve to carry out duties with devotion from the great sons and the leaders of India.

Constitution Day celebrated

Constitution Day was celebrated at the Institute on November 26, 2017 to mark the adoption of the Constitution of India by the Constituent Assembly on this day in the year 1949. The Indian Constitution came into force on 26th of January in 1950. On this occasion, Director of the Institute administered the oath to reiterate the pledge to uphold the Constitution of India.

International Yoga Day organized

On the occasion of International Yoga Day on June 21, 2017, a yoga practice session was organized in the residential premises of the Institute.

Swachchhta Mission observed

The ICAR-IISR, Lucknow observed a campaign on "*Swachchhta Hi Seva*" during September 15-October 2, 2017. The employees took the *Swachchhta Shapath* that they will devote 100 hours per year for observing *Swachchhta* in their homes, *mohallas*, villages and working places. The Institute observed "*Sewa Diwas*" on September 17, 2017, *Samagra Swachchhta Diwas* on September 24, 2017 and "*Sarwatra Swachchhta*" on

September 25, 2017, in which all employees devoted two hours cleaning of the campus and nearby areas. Number of other activities related to sanitation and hygiene were also organized during the campaign.

ICAR-IISR organized ICAR-Inter-Institutional Zonal Sports Tournament for North Zone

Four days ICAR Inter-Institutional Zonal Sports Tournament for North Zone was held in the premises of ICAR-IISR during October 30 – November 2, 2017. In this tournament, total 831 players, including 51 women participated from 24 ICAR Institutes. In all, 34 events were organized and players participated in various sport events like Football, Basketball, Volleyball (Shooting & Smashing), Badminiton, Table Tennis, Kabaddi, Races of various distances viz., 100 m, 200 m, 400 m, 800 m, 1500 m races, 4 x 100 m relay race, long jump, high jump, Javelin throw, Discus throw, Shot put, Chess and Carom etc. The tournament was inaugurated by Dr. S. Solomon, VC, CSAUA&T, Kanpur. At the outset, Dr. A.D. Pathak, Director, ICAR-IISR welcomed all the participants. Dr. S.P. Singh, VC, University of Lucknow was the Chief Guest of Valedictory Session who honoured all the winners by distributing certificates, medals and trophies.

IISR signs MoU to partner with Dr. RML Awadh University

ICAR-IISR, Lucknow has signed a MoU for research collaboration with Dr. RML Awadh University, Faizabad. The agreement was signed by Dr. A.D. Pathak, Director, ICAR-IISR, and Prof. Manoj Dixit, VC, Dr. RML Awadh University, Faizabad.

Grid Connected Roof Top Solar Energy System installed at IISR

A Grid Connected Roof Top Solar Energy System for power generation capacity of 250 kw installed at ICAR-IISR, Lucknow and was inaugurated by Dr. J.S. Sandhu, DDG (Crop Science), ICAR, New Delhi on

June 24, 2017. Speaking on the occasion, Dr. Sandhu appreciated the installation of solar energy system at the Institute and said that this source of green energy will go a long way in reducing the power load on the grid. Dr. A.D. Pathak, Director, ICAR-IISR informed that the installation of this roof top solar power system is expected to save the power bill to the tune of ₹ 24 lakh per year. The Institute has signed a MoU with M/s Genus Innovations Limited, Jaipur for erection, testing and commissioning of grid connected roof top solar power system. The firm will also be responsible for its operation and maintenance for the next 25 years.

Hindi Workshops organized

Four Workshops on Hindi were organized on June 30, 2017; September 22, 2017; December 29, 2017 and March 31, 2018, wherein almost all the Scientists and staff members of the Institute were sensitized to use Hindi in day-to-day official works.

Organization of Hindi Fortnight

Hindi fortnight was organised at the Institute during September 14-29, 2017. Various competitions such as Hindi typing in Unicode, *Antakshari*, Hindi translation, Noting, Writing of Office Order/MoU, *Ashubhashan*, Hindi Quiz, Powerpoint presentations, *Kavi Sammelan* etc., were organized during the fortnight. On this occasion, the winners of the competitions were suitably rewarded.

Meetings of NARAKAS (Office-3) organized

Being chairman office of NARAKAS (Office-3), two meetings were organized at the Institute on June 23, 2017 and November 25, 2017. In the meeting, ten organizations were awarded for doing excellent work in Hindi and three organizations were awarded for *Rajbhasha Patrika*.

ARS-2017 (Preliminary) & 2017 Examination conducted

Agricultural Scientist Recruitment Board (ASRB), New Delhi in search of talent in agricultural research services regularly conducts various examinations all over India. An online examination of Agricultural Research Service (ARS) - 2017 (Preliminary) & National Eligibility Test (NET-I) - 2017 Examination was held the Institute during May 16-21, 2017. Out of 1670 candidates allotted to the centre for 56 disciplines, 1384 candidates appeared in the examination.

CHAPTER 20

New Initiatives

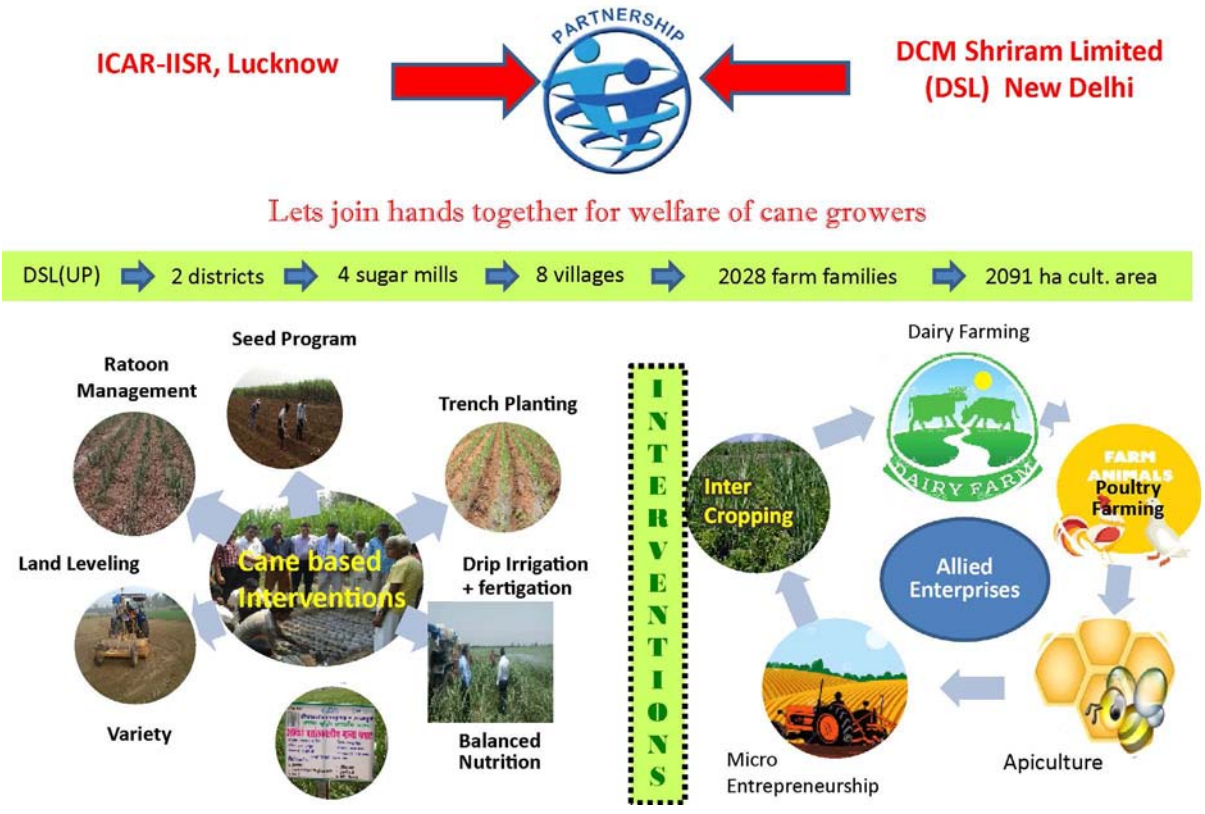
This year, the ICAR-IISR has taken number of new initiatives. Some of the new initiatives taken by the Institute as per the directives of the Government of India/ICAR are given below:

ICAR-IISR initiative for doubling farmers' income in Public Private Partnership Model

To harness the potential of sugarcane sector towards doubling farmers' income, ICAR-IISR has initiated a joint venture with DCM Shriram Limited (DSL), New Delhi in Public Private Partnership mode in command areas of four sugar mills in 2017. The basic objective of the project is to double income of all 2028 farm families in eight villages of two districts by introducing technological, human resource and developmental interventions. ICAR-IISR, Lucknow assessed the existing agri-production system and income level of farmers in the adopted villages and accordingly blue print of required interventions

(sugarcane based and in allied agri enterprises) was prepared and are being implemented with logistic and financial support of DSL group. Functional linkages with development departments, other research institutes, private company like Namaste India and others, NGOs were established.

Doubling Farmers' Income



Out of eight villages, five villages are sugarcane intensive (cane area ranges between 65-91%) and in other three villages, sugarcane coverage was between 6-50%. Sugarcane based interventions like seed cane production, varietal replacement, intercropping, ratoon management, drip irrigation, bio-control, balanced nutrition etc. and interventions in allied agri enterprises like dairying, AH, poultry, fish farming, apiculture, entrepreneurship etc were introduced.

The positive impact of the project is quite apparent as income from sugarcane increased to ₹ 2.25 lac/ha in 2017-18 which was ₹ 1.10 lac/ha in 2015-16. This was possible with introduced intervention in sugarcane based production system. Moreover, marginal and small farmers were largely benefitted. However the overall average annual income of marginal, small and large farmers in base year 2015-16 was assessed at ₹ 53431, ₹ 76346 and ₹ 173168, respectively. The contribution of sugarcane sector in overall income enhancement is expected at about 60-65% and contribution of other allied agri-enterprises is expected at 40-45%.

ICAR ERP (MIS/FMS)

The Council has implemented MIS/FMS software at all of its constituent institutes for online recording and tracking of administrative, financial and research information. Training was provided to institute staff for its implementation in various Divisions and Sections.

ICAR Unified Communications System

All the staff of the institute has been provided with official email under ICAR Unified Communications System to tackle routine messaging services. Both designation-wise and name-wise email-ids were created for the institute under the domain icar.gov.in.

Institute Website

All the information about the institute to its stakeholders are made available through institute website (www.iisr.nic.in). Site has been made bilingual (both Hindi and English) and launched through NIC web server. It is being regularly updated for all the institute events, tenders, jobs, activities, research achievements, staff, publications, etc. Further, a new website of AICRP on Sugarcane has been developed and launched.

AEBAS

Aadhaar Enabled Biometric Attendance System (AEBAS) of the Govt. of India to register the attendance of its employees has been implemented. Registration of employees was made on AEBAS dashboard registered by the institute (http://iisrlko.attendance.gov.in) using their profile, Aadhaar Number and Finger Print registered with UIDAI. As on today, all employees of ICAR-IISR, Lucknow register their attendance using this system only.

ISO Certification

ICAR-Indian Institute of Sugarcane Research, Lucknow got ISO 9001 : 2015 Certification on December 4, 2017 vide Certificate No. BN 18119/16812 for the period of three years.


BSCIC

Certificate

QUALITY MANAGEMENT SYSTEM

ICAR - INDIAN INSTITUTE OF SUGARCANE RESEARCH

RAEBARELI ROAD, P.O. DILKUSHA
LUCKNOW – 226 002, UTTAR PRADESH, INDIA

BN18119/16812

ISO 9001:2015

Provision for Research and Development on Sugar Crops

BSCIC CERTIFICATIONS PVT.LTD.

e-Procurement and e-Publishing

Central Public Procurement Portal (cppp) was launched by the Govt of India as central hub for management of all tenders floated by its offices. e-publishing and e-procurement are two major modules of the system to publish tender online on cppp portal. ICAR-IISR has implemented it and carrying out all its purchase of goods, services and work through e-procurement method i.e. Government-e-Marketplace (GeM).

PFMS and Cashless Transactions

PFMS initiative was made by the Ministry of Finance to provide a central platform to monitor all the financial transactions by central government offices. Registration of the institute along with concerned officials has been made on PFMS website. Currently, all financial transactions are being made using this system.

The Institute was first to implement cashless transaction facility at its campus. PoS machines were obtained with registration of SBI account for different cash counters of the institute.

CHAPTER 21

Distinguished Visitors

Name and Designation	Date of Visit
Sh. Suresh Rana, Hon'ble Cane Development and Sugar Industry Minister, Govt. of Uttar Pradesh	April 12, 2017
Dr. Trilochan Mohapatra, Secretary, DARE & Director General, ICAR, New Delhi	April 12, 2017 & January 12, 2018
Sh. Vipin Kumar Dwivedi, Commissioner, Sugarcane Development and Sugar Industry, Uttar Pradesh	April 12, 2017
Dr. A.K. Singh, DDG (Ag. Extension), ICAR, New Delhi	April 12, 2017
Dr. B.L. Sharma, Director, UP Council of Sugarcane Research, Shahjahanpur	April 12 and May 12, 2017
Sh. Rajneesh Gupta, Principal Secretary (Agriculture), Govt. of Uttar Pradesh	April 17, 2017
Dr. S. Solomon, Vice Chancellor, CSAUA&T, Kanpur	May 12 and October 30, 2017
Dr. Bakshi Ram, Director, ICAR-SBI, Coimbatore	May 12, November 22, 2017 and January 19, 2018
Dr. G.S.C. Rao, Founder and MD, Global Canesugar Services Pvt. Ltd	May 12, 2017
Mr. Yogesh Malik, Additional Cane Commissioner, Govt. of Uttar Pradesh	May 12, 2017
Dr. R.P. Singh, Consultant, IFC, World Bank	May 12, 2017
Sh. Jayant Krishna, Chief Operating Officer, National Skill Development Corporation, Govt. of India	May 13, 2017
Mr. Nitin Deshpande, MD, Trio-Agri, Pune	May 13, 2017
Dr. P.S. Ojha, State Coordinator/Member Convener of UP State Bio-energy Development Board	May 26, 2017
Sh. Surya Pratap Shahi, Hon'ble Minister of Agriculture, Govt. of Uttar Pradesh	June 14 and October 27, 2017
Dr. Rajendra Kumar, Director General, UPCAR, Lucknow	June 14 and October 27, 2017
Sh. Ram Naik, Hon'ble Governor, Govt. of Uttar Pradesh	June 14, 2017
Dr. Mangala Rai, Ex Secretary, DARE & Director General, ICAR, New Delhi	June 14, 2017
Dr. R.B. Singh, Ex. Chairman, ASRB, New Delhi	June 14, 2017
Dr. J.S. Sandhu, DDG (Crop Science), ICAR, New Delhi	June 24, 2017
Mr. R. Sakhalkar, Head-Research & Product Development, Asia Pacific Countries-2, Bayer Crop Science	June 30, 2017
Sh. L. Murali, Director of Sugar & Cane Commissioner, Govt. of Andhra Pradesh	July 11, 2017
Mr. Roshan Lal Tamak, Executive Director, DSCL Sugar	August 19, 2017
Dr. R.C. Srivastava, Vice-Chancellor, Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar	August 28, 2017

Dr. S.S. Pandey, Director, Sugarcane Research Institute, Pusa, Bihar	August 28, 2017
Sh. Kaushal Kishore, Hon'ble MP, Mohanlalganj, Lucknow	August 29, 2017
Dr. Sudhir M. Bobde, Principal Secretary (Animal Husbandry), Govt. of Uttar Pradesh	August 29, 2017 & March 13, 2018
Sh. Sagar Mehra, Joint Secretary (Animal Husbandry), Govt. of India	August 29, 2017
Dr. Sudhir Raizada, ADG (Fisheries), ICAR, New Delhi	August 29, 2017
Sh. Devendra Chaudhary, Secretary (Animal Husbandry, Dairy Development and Fisheries), Govt. of India	August 29, 2017
Sh. Radha Mohan Singh, Hon'ble Minister of Agriculture and Farmers Welfare, Govt. of India	September 10, 2017
Dr. J.K. Jena, DDG (Fisheries), ICAR, New Delhi	September 10, 2017
Dr. P.K. Chhonkar, Adjunct Faculty IARI and Ex-Head, IARI	September 12, 2017
Sh. S.K. Pattanayak, Secretary, Department of Agriculture, Cooperation and Farmers Welfare, Govt. of India	October 6, 2017
Dr. B. Rajender, Joint Secretary (Crops), DAC & FW, Govt. of India	October 6, 2017
Sh. Raj Pratap Singh, Agriculture Production Commissioner, Govt. of Uttar Pradesh	October 6, 2017
Dr. M.N. Singh, Deputy Commissioner (Crops), DAC & FW, New Delhi	October 6, 2017
Dr. P.K. Saha, National Consultant (NFSM), Govt. of India	October 6, 2017
Dr. A.L. Waghmare, Director, Directorate of Sugarcane Development, Lucknow	October 6, 2017
Sh. Kuldeep Singh, Senior General Manager, NSC, Lucknow	October 6, 2017
Sh. Sudhir Garg, Principal Secretary (Agriculture & Horticulture), Govt. of Uttar Pradesh	October 6, 2017
Prof A.K. Sarial, Vice Chancellor, CSKHPKVV, Palampur, HP	October 6, 2017
Dr. G.P. Singh, Director, ICAR-IWBRI, Karnal	October 6, 2017
Dr. I.S. Solanki, Assistant Director General (FFC), ICAR, New Delhi	October 6, 2017
Sh. Soraj Singh, Director (Agriculture), Govt. of Uttar Pradesh	October 6, 2017
Sh. S.K. Khare, MD, U.P. Seed Corporation, Lucknow	October 6, 2017
Sh. V.K. Singh, Director, Statistics & Crop Insurance, Lucknow	October 6, 2017
Shri Harshvardhan Patil, Ex Minister Cooperation (Sugar and Sugarcane), Govt of Maharashtra	October 10, 2017
Shri Prakash Naiknavare, MD, National Federation of Cooperative Sugar Factories, New Delhi	October 10, 2017
Mr. Rishikesh Shukla, Expert and Consultant, National Federation of Sugar Factories, New Delhi	October 10, 2017
Dr. Om Prakash, Former Principal Secretary (Tourism) and Sugarcane Commissioner, Govt. of Uttar Pradesh	October 14, 2017
Shri Vivek Yadav, IAS, Collector and District Magistrate, Vizinagaram	October 16, 2017

Dr. D. Narayana Rao, Managing Director, S.V.G. Cooperative Sugars Limited, Jami Mandal, Vizianagaram	October 16, 2017
Dr. U.S. Gautam, Director, ICAR-ATARI, Zone IV, Kanpur	October 27, 2017
Dr. S.K. Malhotra, Agriculture Commissioner, Govt. of India	October 28, 2017
Dr. R.K. Singh, Assistant Director General (CC), ICAR, New Delhi	November 3 and 22, 2017, February 16 and March 13, 2018
Dr. D.N.S. Yadav, Prof., Dept. of Law, Lucknow University, Lucknow	November 3, 2017
Dr. Prem Kharbandha, CESO Volunteer Advisor, Emeritus Scientist, Alberta Innovates-Technology Futures, Edmonton, Alberta, Canada	November 14, 2017
Dr. A.K. Singh, Deputy Director General (HS & CS), ICAR, New Delhi	November 22, 2017
Prof. Manoj Dixit, Vice Chancellor, Dr. RMLAU, Faizabad	December 7, 2017
Sri Sanjay R. Bhoosreddy, Principal Secretary, Cane Development and Sugar Industries and Cane and Sugar Commissioner, Govt. of Uttar Pradesh	January 19, 2018
Shri S.P. Singh Baghel, Minister of Animal Husbandry, Minor Irrigation and Fisheries, Govt. of Uttar Pradesh	March 13-14, 2018
Shri Laxmi Narayan Chaudhary, Minister of Dairy Development, Religious Affairs, Culture, Minority Welfare, Muslim Waqf and Haj, Govt. of Uttar Pradesh	March 13, 2018
Sh. Anis Ansari, Ex. APC, Govt. of Uttar Pradesh and Chairman, CARD, Lucknow	March 13-14, 2018
Sh. Alok Ranjan, Ex. Chief Secretary, Govt. of Uttar Pradesh	March 13, 2018
Dr. M.J. Khan, Chairman, ICFA	March 13-14, 2018


Dr.A.K. Singh
Dr. A.D. Pathak

CHAPTER 22

Personnel

(As on March 31, 2018)

Director	:	Dr. A.D. Pathak
Crop Improvement		
Principal Scientist & Head	:	Dr. D.R. Malaviya
Principal Scientist (Plant Breeding)	:	Dr. J. Singh
	:	Dr. D.K. Pandey
	:	Dr. P.K. Singh
	:	Dr. Sanjeev Kumar
Principal Scientist (Genetics & Cytogenetics)	:	Dr. Sangeeta Srivastava
Principal Scientist (Genetics)	:	Dr. M. Swapna
Principal Scientist (Agril. Biotechnology)	:	Dr. Sanjeev Kumar
Senior Scientist (Plant Breeding)	:	Dr. A.K. Mall
Scientist (Agril. Biotechnology)	:	Mr. R.S. Gujjar (On study leave)
Senior Technical Officer	:	Mr. Raghvendra Kumar
	:	Mr. Ram Murti
	:	Dr. Ram Kishore
Crop Production		
Principal Scientist & Head	:	Dr. V.P. Singh
Principal Scientist (Agronomy)	:	Dr. T.K. Srivastava
	:	Dr. S.N. Singh
	:	Dr. A.K. Singh
	:	Dr. K.K. Singh
	:	Dr. Chandra Gupta
	:	Dr. M.K. Tripathi
	:	Dr. V.K. Singh
Principal Scientist (Soil Science)	:	Dr. S.R. Singh
Principal Scientist (Agril. Extension)	:	Dr. R.S. Dohare
Senior Scientist (Agronomy)	:	Dr. V.P. Jaiswal
	:	Dr. A.P. Dwivedi
Scientist SS (Soil Science)	:	Dr. R.R. Verma
Scientist (Agronomy)	:	Dr. Dilip Kumar
Chief Technical Officer	:	Mrs. Asha Gaur
Assistant Chief Technical Officer	:	Dr. R.K. Singh
	:	Mr. B.B Singh
Senior Technical Officer	:	Mr. S.N. Srivastava
Technical Officer	:	Mr. A.K. Singh

Crop Protection		
Principal Scientist & Head	:	Dr. M.R. Singh
Principal Scientist (Agril. Entomology)	:	Dr. A.K. Jaiswal
	:	Dr. Sharmila Roy
	:	Dr. S.N. Sushil
	:	Dr. Arun Baitha
Principal Scientist (Plant Pathology)	:	Dr. S.K. Duttamajumder
	:	Dr. Dinesh Singh
Sr. Scientist (Plant Pathology)	:	Dr. Deeksha Joshi
Chief Technical Officer	:	Dr. D.C. Rajak (On deputation)
Senior Technical Officer	:	Mrs. Pramila Lal
Technical Officer	:	Mr. I.P. Maurya
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 (SWCE)	:	Dr. Rajendra Gupta
Principal Scientist (AS &PE)	:	Dr. Dilip Kumar
Senior Scientist (FMP)	:	Er. Sukhbir Singh
Chief Technical Officer	:	Mrs. Mithilesh Tiwari
Assistant Chief Technical Officer	:	Mr. M.H. Ansari
	:	Mr. Suresh Kumar Kushwaha
	:	Mr. Vinayak Sawant
	:	Mr. Krishna Nand Singh
	:	Mr. Rajiv Ranjan Rai
Senior Technical Officer	:	Mr. Umesh Kumar
	:	Mr. Sunil Kumar Mishra
Technical Officer	:	Mr. Chaman Singh
	:	Mr. Surya Dev Singh
	:	Mr. Lakhan Lal Verma
Plant Physiology & Biochemistry		
Principal Scientist & Head	:	Dr. Radha Jain
Principal Scientist (Economic Botany & Plant Genetic Resources)	:	Dr. M.M. Roy
Principal Scientist (Plant Physiology)	:	Dr. R.K. Rai
Principal Scientist (Biochemistry)	:	Dr. Amaresh Chandra
Principal Scientist (Organic Chemistry)	:	Dr. Pushpa Singh
Senior Scientist (Plant Physiology)	:	Dr. S.P. Singh
Scientist (Biochemistry)	:	Mr. Rajeev Kumar
Assistant Chief Technical Officer	:	Mr. C.P. Singh
	:	Mrs. Anita Sawnani
Technical Officer	:	Mr. R.K. Singh

PME Cell & ITMU		
Nodal Officer & In-charge	:	Dr. L.S. Gangwar
Chief Technical Officer	:	Mr. Brahm Prakash
Assistant Chief Technical Officer	:	Mr. A.K. Sachan
Senior Technical Officer	:	Dr. Y.P. Singh
AKMU		
Principal Scientist & In-charge	:	Dr. Rajesh Kumar
Principal Scientist (Agril. Economics)		Dr. A.K. Sharma
	:	Dr. L.S. Gangwar
Principal Scientist (Computer Application)	:	Dr. S.S. Hasan
Chief Technical Officer	:	Dr. Mani Ram Verma
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	:	Mr. Nar Singh
Assistant Chief Technical Officer	:	Dr. Om Prakash
	:	Mr. A.K. Singh
Juice Lab		
Senior Scientist and Incharge	:	Dr. S.P. Singh
Assistant Chief Technical Officer		Mrs. Meena Nigam
AICRP on Sugarcane		
Project Coordinator	:	Dr. S.K. Shukla
Principal Scientist (Plant Breeding)	:	Dr. V.K. Gupta
Principal Scientist (Entomology)	:	Dr. Arun Baitha
Scientist (Agronomy)	:	Dr. Sanjai Yadav
Scientist (Plant Pathology)	:	Dr. Lalan Sharma
Chief Technical Officer	:	Dr. S.K. Awasthi
	:	Dr. G.K. Singh
Assistant Chief Technical Officer	:	Mr. Adil Zubair
Farm		
Principal Scientist & In-charge	:	Dr. A.K. Singh
Farm Managar (Chief Technical Officer)	:	Dr. B.B. Joshi
Assistant Chief Technical Officer	:	Mr. Surendra Singh
Senior Technical Officer	:	Mr. Faujdar Singh
Technical Officer	:	Mr. J.P. Pandey
	:	Mr. A.P. Dubey
	:	Mr. Sanjay Gautam
Krishi Vigyan Kendra		
Principal Scientist & In-charge	:	Dr. S.N. Singh
Assistant Chief Technical Officer	:	Mr. Devendra Singh

SMS (Animal Science)	:	Dr. R.K. Singh
SMS (Home Science)	:	Dr. Veenika Singh
SMS (Plant Protection)	:	Dr. Deepak Rai
SMS (Horticulture)	:	Dr. Vivekanand Singh
Rajbhasha Prakoshtha		
Principal Scientist & In-charge	:	Dr. A.K. Sah
Technical Officer	:	Mr. A.K. Singh
Art & Photography		
Principal Scientist & In-Charge	:	Dr. L.S. Gangwar
Chief Technical Officer	:	Mr. Vipin Dhawan
Assistant Chief Technical Officer	:	Mr. Y.M. Singh
Senior Technical Officer	:	Mr. A.K. Yadav
Dispensary		
In-charge	:	Mr. Rishi Ram
Assisstant Chief Medical Officer	:	Dr. S.K. Sethi
Library		
Principal Scientist & In-Charge	:	Dr. Sharmila Roy
Assistant Chief Technical Officer	:	Mr. Ghanshyam Ram
Senior Technical Officer	:	Mr. R.N.P. Bharti
Unit In-charges		
In-charge, Seed Production Unit	:	Dr. Sanjeev Kumar
In-charge, Vehicle	:	Mr. R.K. Yadav
In-charge, Landscaping	:	Mr. Shridhar Tiwari
In-charge, Guest House	:	Mr. Rishi Ram
Caretaker, Guest House	:	Mr. Nag Chand
IISR Regional Centre, Motipur (Bihar)		
Senior Scientist & In-charge	:	Dr. A.K. Mall
IISR Biological Control Centre, Pravaranagar (Maharashtra)		
Nodal Officer	:	Dr. S.N. Singh
Scientist (Plant Pathology)	:	Dr. S.K. Holkar
Scientist (Microbiology)	:	Dr. D.N. Borase
Scientist (Nematology)	:	Mr. Y.E. Thorat
Administration		
Senior Administrative Officer	:	Mr. Rishi Ram
Finance & Accounts Officer	:	Mr. Raja Ram
Assistant Administrative Officer	:	Mr. R.K. Yadav
	:	Mr. V.P. Tiwari
	:	Mr. S.K. Bagchi
	:	Mr. A.M. Srivastava
Private Secretary	:	Mr. Rajeev Arora
	:	Mr. Prem Chandra
Security Officer	:	Mr. C.P. Prajapati

Appointment

Name	Post	Date of joining
Sh. Rajeev Kumar	Scientist (Plant Biochemistry)	April 15, 2017

Transfers

Name and Post	From	To	Effective from
Joining IISR			
Dr. Dilip Kumar, Scientist (Agronomy)	ICAR-IISWC RC, Agra	ICAR-IISR, Lucknow	July 7, 2017
Dr. D.N. Borase, Scientist (Agril. Microbiology)	ICAR-IIPR, Kanpur	ICAR-IISR, Lucknow	July 7, 2017
Dr. A.K. Jaiswal, Principal Scientist (Agril. Entomology)	ICAR-IINRG, Ranchi	ICAR-IISR, Lucknow	July 10, 2017
Dr. M.K. Tripathi, Principal Scientist (Agronomy)	ICAR-CRIJAF, Barrackpore	ICAR-IISR, Lucknow	July 7, 2017
Mr. Jata Kant, Assistant	ICAR-PDFSR, Meerut	ICAR-IISR, Lucknow	July 20, 2017
Mrs. Kirti Singh, Assistant	ICAR-IIPR, Kanpur	ICAR-IISR, Lucknow	December 14, 2017
Leaving IISR			
Mr. Inder Singh, Senior Technician	ICAR-IISR, Lucknow	ICAR-IISWC, Dehradun	March 9, 2018

Promotions

Name	Promoted to	Date of promotion
Scientists		
Dr. R.R. Verma, Scientist (Soil Science)	Scientist (RGP Rs. 7,000/-)	January 8, 2011
Dr. S.K. Holkar, Scientist (Plant Pathology)	Scientist (RGP Rs. 7,000/-)	January 1, 2017
Dr. S.R. Singh, Senior Scientist (Soil Science)	Principal Scientist	July 17, 2015
Dr. Sanjeev Kumar, Senior Scientist (Agril. Biotechnology)	Principal Scientist	November 5, 2015
Dr. Barsati Lal, Senior Scientist (Agril. Extension)	Principal Scientist	November 2, 2014
Dr. V.K. Singh, Senior Scientist (Agronomy)	Principal Scientist	December 21, 2015
Dr. Dilip Kumar, Senior Scientist (AS&PE)	Principal Scientist	December 21, 2015
Technical		
Mrs. Asha Gaur, Asstt. Chief Tech. Officer	Chief Tech. Officer	January 1, 2017
Mrs. Mithilesh Tiwari, Asstt. Chief Tech. Officer	Chief Tech. Officer	January 9, 2017
Mrs. Meena Nigam, Senior Tech. Officer	Asstt. Chief Tech. Officer	January 1, 2017
Mrs. Neelam Singh, Tech. Officer	Senior Technical Officer	October 15, 2016
Mr. Ram Murti, Senior Tech. Officer	Asstt. Chief Tech. Officer	November 17, 2012
Dr. S.K. Awasthi, Chief Tech. Officer	One Advance Increment	February 3, 2017
Mr. Kalpnath, Technical Assistant	Sr. Technical Assistant	June 26, 2017
Mr. M.P. Tripathi, Senior Technician	Technical Assistant	October 20, 2016
Mr. Inder Singh, Technician	Senior Technician	July 23, 2017
Administrative		
Mr. Rajeev Arora, PS	MACP	
Mr. Sunder Lal, Assistant	MACP	
Mrs. Chaman Ara Siddiqui, Assistant	MACP	
Mr. Sanjay Mishra, UDC	MACP	

Retirements

Name	Post	Date of retirement
Mr. Someshwar Mishra	Technical Officer	June 30, 2017
Mr. Shatrughan	Skilled Supporting Staff	July 31, 2017
Dr. K.P.Singh	Principal Scientist (Agronomy)	August 31, 2017
Mr. Mustafa Ali	Skilled Supporting Staff	November 30, 2017
Mr. D.N. Sinha	Technical Officer	November 30, 2017
Dr. Anil Kumar Singh	Principal Scientist (Plant Pathology)	December 31, 2017
Mr. Sanjay Bhatnagar	Chief Technical Officer	December 31, 2017
Mr. Kunwar Kailash	Technician	December 31, 2017
Mrs. Neelam Singh	Senior Technical Officer	January 31, 2018
Mr. B.N. Ram	Technical Officer	January 31, 2018
Mr. Kuldeep Singh	Assistant	February 28, 2018
Mr. M.P. Sharma	Asstt. Chief Technical Officer	March 31, 2018
Mr. Julianus Minz	Technical Officer	March 31, 2018

CHAPTER 23

Meteorological Data

Month	Temperature (^{0}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, 17	22.0	7.8	94.6	51.5	16.5	2	5.7	1.4	1.7
February, 17	25.8	10.3	91.3	36.3	0.4	0	6.3	2.6	2.9
March, 17	31.8	17.1	75.8	25.3	5.4	1	9.3	5.0	4.5
April, 17	38.4	22.2	60.6	24.2	0.0	0	9.6	7.4	4.1
May, 17	39.5	24.9	67.1	31.6	18.4	2	9.6	7.4	3.5
June, 17	38.7	26.8	74.4	43.5	85.0	4	8.3	6.6	3.1
July, 17	32.6	25.9	91.3	78.0	336.4	15	3.9	2.8	2.2
August, 17	33.3	26.3	91.9	75.4	232.2	12	4.0	2.6	2.6
September, 17	34.3	25.4	90.5	63.9	54.0	2	6.8	2.1	2.1
October, 17	34.3	19.9	95.6	45.4	0.0	0	7.6	2.8	1.0
November, 17	28.3	11.7	93.6	41.5	0.0	0	5.7	1.9	1.2
December, 17	24.3	8.7	94.4	45.0	0.4	0	4.4	1.3	1.6
January, 18	20.4	5.4	80.7	51.7	4.0	1.0	4.9	1.3	1.9
February,18	26.8	10.4	89.1	38.6	0.0	0.0	7.3	3.4	3.2
March, 18	33.6	15.6	73.1	24.5	0.0	0.0	9.1	6.4	4.3

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