भाकृअनुप
ICAR

भारतीय गन्ना अनुसंधान संस्थान, लखनऊ

Annual Report
2016-17

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ICAR-Indian Institute of Sugarcane Research, Lucknow

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ICAR-Indian Institute of Sugarcane Research
Lucknow - 226 002, Uttar Pradesh, India
Tel: +91-522-2480726, 2961318; Fax: +91-522-2480738
E-mail: director.sugarcane@icar.gov.in
Website: www.iisr.nic.in

Published by : **Dr. A.D. Pathak**
Director
ICAR-Indian Institute of Sugarcane Research
Raebareli Road, P.O. Dilkusha
Lucknow 226 002, U.P.

Compiled and edited by : **Dr. S.K. Shukla,** Project Coordinator (Sugarcane)
Dr. S.K. Duttamajumder, Principal Scientist
Dr. L.S. Gangwar, Principal Scientist
Dr. A.K. Sharma, Principal Scientist
Dr. S.P. Singh, Senior Scientist
Dr. A.K. Mall, Senior Scientist
Sh. Brahm Prakash, Chief Technical Officer
Sh. Atul Kumar Sachan, Assistant Chief Technical Officer

Photographs by : **Shri Vipin Dhawan,** Chief Technical Officer
Shri Y.M. Singh, Assistant Chief Technical Officer
Shri A.K. Yadav, Senior Technical Officer

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Preface

Sugarcane is an important agro-industrial crop contributing immensely to the socio economic development of rural India and provides means of livelihood to about 7.5 million farmers engaged in its cultivation and direct employment opportunity to around 0.60 million workers in sugar mills. The challenges faced by the Indian sugar sector comprise of fulfilling the increasing sugar and energy demand and to overcome natural resource degradation, low farm income, escalating cost of production, labour scarcity, global trade regulations and a paradigm shift in implementation of policies for sustainable development of agriculture. By 2030, India would require 33 million tonnes of white sugar and 9 million tonnes of jaggery, 10.94 million tonnes of bio-ethanol and 48 million carbon credits. ICAR-IISR is untiringly working for this sector since its inception to achieve the future targets and challenges of enhancing farmers' profitability, sugarcane production and sustainability of sugar sector in the country.

Stagnant productivity and poor sugar recovery were the picture of sugarcane farming in Uttar Pradesh. Through concerted efforts, sugarcane productivity and sugar recovery have increased from 59.6 to 72.30 t/ha and 9.18% to 10.61%, respectively during last five years in the State. This has become reality due to adoption of CVRC released sugarcane varieties such as Co 0238, CoLk 94184, Co 98014, Co 0118, CoPK 05191 etc., in the State. Proportion of sugarcane area under early maturing varieties has increased from nearly 9.26 to 52.8%. This year, sugar mills in U.P. have achieved all time record of sugar production and produced 8.75 million tonnes which is 23% higher as compared to the previous season (2015-16). In Uttar Pradesh, the Institute had implemented cane development programmes in collaboration with State cane department and sugar mills. It has culminated in record sugarcane productivity of 72.30 tonnes/ha. All the stakeholders have contributed immensely in achieving this great success in the State. The Institute introduced technological interventions in participatory mode with sugar mills, State cane department and farmers to execute various schemes and programmes. Non- availability of quality seed cane was major problem for replacing old and denotified varieties with improved ones. This issue was adequately addressed with the implementation of entrepreneurship development programme in seed cane production. The better adoption of technological interventions and equipment developed by ICAR-IISR helped in reducing cost of sugarcane production and led to a productivity enhancement to the tune of 15-20 t/ha. Interactive meetings and interface with all stakeholders are being organized regularly to formulate strategies, implementation and concurrent evaluation. The R&D efforts to implement the three-tier sugarcane seed production, multiplication and distribution programme of improved varieties by the Institute has shown encouraging results in enhancing productivity and sugar recovery in Uttar Pradesh. Now, U.P. has become the torch bearer and for the first time, has surpassed national average of productivity and sugar recovery.

For doubling farmers' income by 2022, ICAR-IISR has formulated strategies and initiated various programmes for increasing net returns by reducing costs in sugarcane based farming system. The Institute has promoted organic jaggery production processed through IISR model furnace, moulding and

packaging accessories for skill development of rural youth in the sugarcane producing areas where sugar mills are either closed or not working efficiently.

It is my pleasure to present the Annual Report of the Institute comprising research and development activities undertaken by the Institute during 2016-17. The all-round growth and development of the Institute has been possible with the able guidance, encouragement and continuous support received from Dr. T. Mohapatra, Secretary, DARE and Director General, ICAR and Dr. J.S. Sandhu, Deputy Director General (Crop Science), which I acknowledge with sincere gratitude and respect. The active support and encouragement received from Dr. R.K. Singh, Assistant Director General (CC) in carrying out various activities is duly acknowledged.

I would like to appreciate Drs. M.R. Singh, Radha Jain, D.R. Malaviya, V.P. Singh and A.K. Singh, all Head of Divisions, for their sincere efforts in compiling and editing the report of their respective Divisions. The sincere efforts of Dr. S.K. Shukla, Dr. S.K. Duttamajumder, Dr. L.S. Gangwar, Dr. A.K. Sharma, Dr. S.P. Singh, Dr. A.K. Mall, Mr. Brahm Prakash and Mr. A.K. Sachan in compiling editing and bringing out the report are highly appreciated.

Date : June 30, 2017

(A.D. Pathak)
Director

Contents

Executive Summary

Crop Improvement

- CoLk 09204 (Ikshu-3) a mid-late maturing sugarcane variety (Parentage, CoLk 8102 × CoJ 64), identified in the Workshop of AICRP(S) for cultivation in North West Zone. It is a result of concerted efforts of breeding for high sugar (17.0%) and high yield (82.8 t/ha).
- Ten sugarcane genotypes have been accepted for multi-location evaluation under AICRP(S), including two early (CoLk 16201 and CoLk 16202) and two mid-late (CoLk 16203 and CoLk 16204) for North-West Zone and three early (CoLk 16466, CoLk 16467 and CoLk 16468) and three mid-late (CoLk 16469, CoLk 16470 and CoLk 16471) genotypes for evaluation in North Central Zone.
- Genotypes LG 10803 and LG 11819 were MR to red rot, (Cf 01, Cf 08 and Cf 09) with >17% sucrose and LG 10805, LG 11816, LG 11842 were R to red rot (Cf 08), >18% sucrose and >88 t/ha cane yield. These genotypes were identified for AICRP(S) multilocation trials.
- Institute is maintaining collection of 339 genotypes consist of 30 species level genotypes (*Saccharum officinarum*, *S. barberi*, *S. sinense*), ISH & Ikshu ISH clones (51), LG selections (71), commercial hybrids (162) and somaclonal variants (25).
- Based on agronomic characters, HR Brix (%) and sucrose (%), 16 clones from different crosses of C_2 generation were selected.
- Chromosome studies with CoLk 8102 and its clonal population revealed the modal chromosome number 2n=ca 108. In third clonal progeny population, modal chromosome numbers ranged from 92-112 and the range of chromosome number variation got narrowed over generations.
- Ninety two sugarcane varieties from sub-tropical India were subjected to molecular profiling with 174 SSR markers and characterized for 23 qualitative and nine quantitative traits. Using STRUCTURE-based population stratification study and a mixed linear model (MLM) for MTA analysis, a total of 60 MTAs were identified for 22 qualitative traits.
- Using panel of 119 sugarcane genotypes fingerprinted for 944 SSR alleles, four marker-trait associations (MTAs) for resistance to red rot were identified.
- Rapid *in vitro* clonal propagation of sugarcane varieties, CoLk 9709, CoLk 09202, Co 05011, Co 06034 and Co 0238 was achieved through enhanced axillary shoot proliferation using apical shoot explants with successful field transfer.
- Under *in vitro* preservation of sugarcane, the shoot-tip explants of genotype Khakai on MS medium with 2.22 µM BA, 0.5 µM Kinetin, 0.5 µM GA_3 and supplemented with 10% sucrose survived for 365 days without any subculture.
- Phenotyping of two parents and 262 F_1s for TSS, NMCs, leaf width and cane diameter and cane length has been completed. RNA sequencing libraries of two parents and two extreme bulks were prepared and sequenced using paired-end chemistry on Illumina platform.
- The genetic transformation parameters in variety Co 0238 has been established using *A. tumefaciens* strain LBA4404 containing the binary vector pCAMBIA 2301 habouring *nptII* and *gus* reporter genes. Leaf roll explants were tested for transient GUS expression. Putative transformants were screened using PCR for *gus* as well as *nptII* gene-specific primers.
- During this year, ~8000 q of seed cane of improved varieties of sugarcane was produced and ~6000 q seed cane was distributed to farmers/sugar mills.

Crop Production

- Validation of cane node technology in field condition proved its superiority over the conventional three bud sett planting. Crop under this system had better germination, tillers and more number of millable canes.
- High ratoon cane yield (62.8 t/ha and 58.2 t/ha) was recorded at N level of 200 kg/ha and K level of 90 kg/ha. The significant residual effect of zinc on ratoon cane yield (64.6 t/ha) was recorded up to 15 kg/ha along with phosphorus 60 kg/ha.
- Initial soil organic carbon (SOC) level up to 0.56-0.65% caused significant increase in number of tillers at 120 and 180 DAI over SOC level 0.45-0.55%. The highest NMC (116.1 thousand/ha) was recorded with 0.66-0.75% SOC. Ratoon yield increased significantly with increasing SOC content and the highest cane yield (83.4 t/ha) was attained with > 0.76%. Higher SOC (0.56-0.65%) caused significant increase in cane thickness.

- The highest rate of ratoon stubble sprouts (83.6%) was observed under 20 t FYM + STRC nutrient application followed by the treatment of only organic application. The highest number of tillers, shoot count, number of millable canes, cane yield (89.4 t/ha) and sugar yield (9.87 t/ha) were recorded under treatment of FYM @20 t/ha along with soil test (rating chart) based inorganic fertilizer recommendations.
- Growing of plant crop with recommended dose of fertilizers (RDF) in water logging conditions was found beneficial in respect of maintaining SOC, available N, P, K and S without significant changes in pH and EC values. Zn content was higher with RDF application in water logging conditions but Fe and Mn were the highest in sub-optimum conditions. Fungal and *Azotobacter* counts were higher in optimum conditions under farmers' practice but bacterial and actinomycetes counts were higher in RDF under different sugarcane growing system.
- The average contribution of MDS towards development of SQI was found in order of K (15.8%)>SOC (14.4%)> Fe(13.6),> Na (12.1%)>Zn (11.9%) >TCB (6.10%). The highest SQI (0.80) was recorded in RDF under water logging conditions followed by RDF (0.78) in optimum condition and the lowest (0.67) was with FP under sub-optimum.
- The highest sugarcane yield of 94.43 t/ha was observed in drip fertigation treatment with irrigation water equal to 1.25 times pan evaporation and nitrogen equal to 100% of recommended dose. Drip fertigation influenced irrigation water use efficiency (IWUE) significantly. The highest IWUE of 2090.7 kg/ha-cm was recorded when sugarcane was irrigated with water equal to 0.75 times pan evaporation and nitrogen equal to 75% of recommended dose.
- Paired-row trench planting with trash mulching (120.97 t/ha) was at par with conventional flat method of planting along with trash mulching (115.19 t/ha) resulted in significantly higher cane yield than that of conventional flat method of planting (109.86 t/ha). The trash application led to higher sugarcane yields irrespective of irrigation scheduling. The WUE was maximum under paired-row trench planting with trash mulching (0.80 t/ha-cm) followed by conventional flat method of planting with trash mulching (0.76 t/ha cm) and paired-row trench planting (0.75 t/ha- cm).
- The performance of different early genotypes showed that the highest tillers at 120 DAP, shoot count at 240 DAP and NMC was registered with genotype CoLk 11203 and the lowest with CoH 11262. However, the highest stalk length (2.40 meter), single cane weight (1.34 kg) and cane yield (76.81 t/ha) was recorded with Co 0238-a check variety for the trial. Similarly, the highest brix, sucrose and purity % measured at 8 and 10-month was recorded with CoLk 11203, which was at par with Co 0238.
- Germination % at 45 DAP revealed that mid-late genotype CoLk 11206 was at par with genotypes CoPb 11214, CoS 8436 and Co S 767 but was superior to CoH 11263, Co Pant 97222, CoLk 11204 and Co 11027. Cane yield was the highest in genotype CoLk 11206 (80.76 t/ha) but was at par with CoPb 11214. Cane height was higher in genotype CoLk 11206 over rest of the seven genotypes tested. Genotype Co 11027 gave the highest brix%, sucrose and purity % measured at 12-month stage.

Crop Protection

- A survey was conducted for occurrence of sugarcane insect pests and diseases on commercial plantations in 12 sugar mill command areas of Uttar Pradesh, Bihar and Maharashtra and incidence of major insect and pests were recorded.
- Yellow leaf disease (YLD) recorded in 26 sugarcane genotypes on cane basis ranged from 1.25% to 29.95%. The incidence was higher (44.45%) in CoS 91230.
- At the crop age of 350 days, all the treated canes were found infected with the YLD except in serial thermotherapy for two hours through MHAT at 50°C for three consecutive days.
- Thirty nine sugarcane genotypes were evaluated against two pathotypes of red rot (Cf 08 and Cf 09). Out of 39 genotypes, 18 were found resistant (R) to moderately resistant (MR) against both the pathotypes. Eight genotypes were found resistant (R) to moderately resistant (MR) against Cf 08 and susceptible (S) to Cf 09.
- Soil treatment with TMC as well as in combination with sett treatment were found more effective against red rot over control (43% to 56.3% reduction in red rot incidence) as compared to sett treatment alone (35% reduction).
- In III brood, incidence of top borer was low in all the varieties, it ranged from 0.00 to 7.22%. In IV brood, incidence of top borer was maximum in Co 0238 (10.34%) followed by CoSe 92423 (8.13%).
- *Isotima javensis* accepted top borer larvae only while *Stenobracon nicevillei* accepted both of the larvae for

parasitisation but required two larvae of *Corcyra cephalonica* to complete its life cycle.

- Incidence of top borer was 21.67, 23.04, 25.85, 27.27, 29.81 and 41.36% when intercropped with marigold, mustard, coriander, brinjal, tomato and sole sugarcane, respectively. Incidence of III and IV brood ranged between 8.81 and 14.37% & 7.10 and 13.57%, respectively in various trap crop plots against sole sugarcane (15.62 and 13.57%). The incidence of internode borer was the lowest in sorghum and maize (26-29%) followed by other trap crops (30.87-37.02%) and sole sugarcane (40.07%).
- The parasitisation of top borer larvae (III and IV brood) by *Rhaconotus scirpophagae, Isotima javensis* and *Stenobracon nicevillei* was observed as 16-26.33% and 25.66-39.66%, respectively in various trap crops as compared to sugarcane sole crop (10.41 and 22.33%).
- In top borer (III Brood), egg parasitisation in plots treated with egg extract was 66.67, 80.00 and 70.00 per cent as against 40.00, 50.00 and 40.00 per cent in untreated plots of CoLk 8102, CoJ 64 and Co 0238, respectively. The larval parasitisation by *Rhaconotus* in CoLk 8102 and CoJ 64 was higher (40 and 60%) over untreated control (20 and 40%).
- The larval parasitisation by *Rhaconotus* in CoLk 8102 and CoJ 64 was higher (60%) over untreated control (20 and 40%), Parasitisation by *Stenobracon* spp was higher (40%) in CoLk 8102.
- For the management of borer complex (early shoot, internode and top borer), egg parasitoid *Trichogramma chilonis* was mass multiplied on *Corcyra cephalonica* and a total of 1,09,50,000 adults of *Trichogramma chilonis* (as Trichocards) were released in 547.50 acre of sugarcane crop.
- For the rearing of egg parasitoid, *Eumicrosoma* sp. (parasitoid of black bug), about 50 fresh eggs of a black bug, *Dimorphopterus gibbus* (Fab.) were offered to five pairs of parasitoid, *Eumicrosoma* spp. in glass vials. It was reared successfully throughout the year.
- Lure septa for top borer were changed at 20 days intervals. Incidence of top borer III and IV brood in plot with sex pheromone traps was low.

Plant Physiology and Biochemistry

- Application of Ethrel and GA_3 boosted yield of autumn planted crop to 274 t/ha against 330 t/ha in 2014-15 at IISR farm and 258 t/ha against 108 t/ha in control of spring planted crop at Motipur.
- *In situ* decomposition of trash along with GA_3 led to an increase in cane yield of 16.9 t/ha than those of GA_3 alone in Ist ratoon initiated from spring planted crop.
- Foliar application of enzyme effectors (ethrel @ 100, 200, 400 ppm, Mg + Mn and Chemical formulation) at the onset of ripening enhanced sucrose content in CoJ 64 and BO 91 in all the treatments. The highest increase was obtained with 200 ppm ethrel and 200 ppm ethrel + Mg + Mn.
- Waterlogging affected plants showed reduced single cane weight, leaf chlorosis, aerial rooting and increased activities of ADH, APX and SOD enzymes. The highest activity was observed in BO 91. Genotypes D-6-13, LG 05350, CoLk 94184, UP 9530 and LG 03040 are grouped as waterlogging tolerant.
- For transcriptome analysis, total RNA from top and bottom internodes of GA_3 sprayed and unsprayed cane samples of variety CoLk 94184 were isolated and quality of RNA was checked. Transcripts were sequenced using Illumina HiSeq 2×100bp chemistry and a total of 32 GB data were generated. After bioinformatics, various data sets including *de novo* assembly, gene expression, annotation, GO and pathway, SNP and SSR were generated. Average length of contig was 707 bps. ~ 3000 transcripts observed were significant differentially expressing.
- Cell wall invertase (CWI) that plays key role in phloem unloading in sink tissues, exhibited higher expression in GA_3 samples at the elongation stage which decreased with maturity, whereas both sucrose synthase (SuSy) and sucrose phosphate synthase (SPS), involved in regulation of sucrose accumulation, showed variable expression.
- Study carried out using potent bactericidal and anti-inversion chemicals indicated that Benzalkonium chloride (BKC) was better to control post-harvest losses. A BKC concentration of 1000-2000 ppm was found most suitable checking the juice quality deterioration. Results indicated a significant quantitative change in the expression of SAI in control, BKC and BKC+SMS treated canes.
- The species specific primer for *Leuconostoc lactis* produced a PCR product of the expected molecular weight (742bp) with all twenty three isolates. The other species specific primers set namely *L. argentinum, L. carnosum, L. citreum, L. fallax, L. gelidum, L. mesenteroides* and *L. pseudomesenteroides* did not produce any PCR product. DNA sequencing of the 13 selected isolates revealed high homology in 16S rDNA nucleotide sequences. A

BLAST against other sequences from reference strains in the GenBank revealed a 98% homology with *L. lactis*.

Agricultural Engineering

- Prototype of tractor operated deep furrow sugarcane cutter planter was evaluated. It is a multitasking equipment which performs different operations involved in cane planting and putting a soil cover over setts and compacting with a tamping roller, simultaneously. It took five hours for planting of one hectare with four persons against 40-45 man-days in manual planting. The cost of operation of sugarcane planting was saved by 60%.
- Battery operated spraying attachment was developed and integrated with the deep furrow planter for spraying of herbicide after soil covering. Four man-days were saved by using the machine.
- Prototype of tractor operated deep furrow (modified RBS cane planter) was designed, developed and tested. It performs planting of two rows of sugarcane in deep furrows and sowing of two rows of companion crop on raised beds between the two furrows, simultaneously in single pass. Machine was tested at IISR farm for planting of intercrops under FIRB method. Effective field capacity of the planter was 0.18-0.20 ha/h.
- Tractor operated two rows sugarcane-cum-potato planter was designed and developed. Effective field capacity of the planter was 0.127 ha/h at forward speed of 0.5 m/s. The planter saved 90% labour and ₹ 10,440 per ha (76%) cost as compared to conventional method.
- Tractor operated multipurpose tool frame was designed and developed to attach different equipments for sugarcane cultivation.
- Two separate prototypes of tractor operated two row disc type ratoon management device with and without stubble saving attachments were fabricated. Effective field capacity of the prototypes ranged from 0.25 to 0.35 ha/h.
- Prototype of tractor operated cane node planter was designed and developed for mechanizing cane node planting. Field testing was conducted to evaluate the performance of the planter. Power operated cane node cutting machine was also developed.

Agricultural Extension

- The appraisal of four villages in Lakhimpur Kheri district was carried out. The prevailing cropping patterns and crop sequences, cropping intensity in sugarcane based farming system were recorded. The problems associated with crops and factors limiting productivity of sugarcane were ascertained. Receptiveness of the farmers was studied to know the degree of farmers' inherent interest.

Agricultural Economics, Statistics and ICT

- Sugar prices increase lead to better revenue realization and give boost to economic viability of sugar sector in short run. The Govt. of U.P. enhanced sugarcane SAP @ ₹ 25 per quintal after three seasons. Effective policy and realistic decision should be taken by the Government to strengthen sugar sector.
- Production constraints and factors affecting sugarcane yield and sugar recovery have been identified for different agro-climatic zones of U. P. Though labour scarcity, cost escalation, cultivation of rejected varieties, non-judicious use of IPM, INM, it is noteworthy that cane productivity, recovery and sugar production has improved significantly. Sugarcane fetches better economic return and has low production risk as compared to other competing crops.
- U.P. Government permitted the cultivation of CVRC released varieties in 2011-12 which paved the way for wider adoption of superior varieties such as Co 0238, Co 0118, CoLk 94184, Co 98014 in U.P. Its economic impact was visualized as productivity gain 10-15% and sugar recovery 10.61%. This is a remarkable achievement during sugar season 2015-16 and 2016-17. Both farmers and sugar mills have benefitted. Economic gains nearly ₹ 1790 crores to farmers were realized.
- In U.P., 10.61% sugar recovery was realized and 8.75 million tonne sugar was produced during crushing season 2016-17.
- The cost of sugarcane cultivation and its processing has increased substantially. The cost of sugar processing varied from ₹ 32,658 to ₹ 40,865/ tonne with ex-mill sugar price ₹ 36,500-38,300 per tonne in stand alone integrated sugar-energy complex owned by cooperative or private sector.
- In zonal varietal trials under AICRP(S), 23 genotypes were identified which possess high yield, sustainability and low sensitivity to adverse environmental conditions. These genotypes may be considerd as climate resilient for different zones.
- Data repository for mining purpose should have strong data integration and exploration capabilities for analysis and reporting. Dimension modelling technique has been incorporated for development of such repositories.

About the Institute

The Indian Institute of Sugarcane Research (IISR), Lucknow was established in 1952 by the Indian Central Sugarcane Committee for conducting research on fundamental and applied aspects of sugarcane culture as well as to co-ordinate research work done on this crop in different states of the country. The Government of India took over the Institute from the Indian Central Sugarcane Committee on January 1, 1954, and thereafter, it was transferred to the Indian Council of Agricultural Research (ICAR), New Delhi on April 1, 1969. The Institute is located in Lucknow, the capital city of Uttar Pradesh and conveniently situated at about 12 km from CCS Airport, Amausi and about 5 km from Lucknow Railway Station. The climate of the area is sub-tropical semi-arid type. Monthly average maximum temperature during April to June ranges from 36^{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

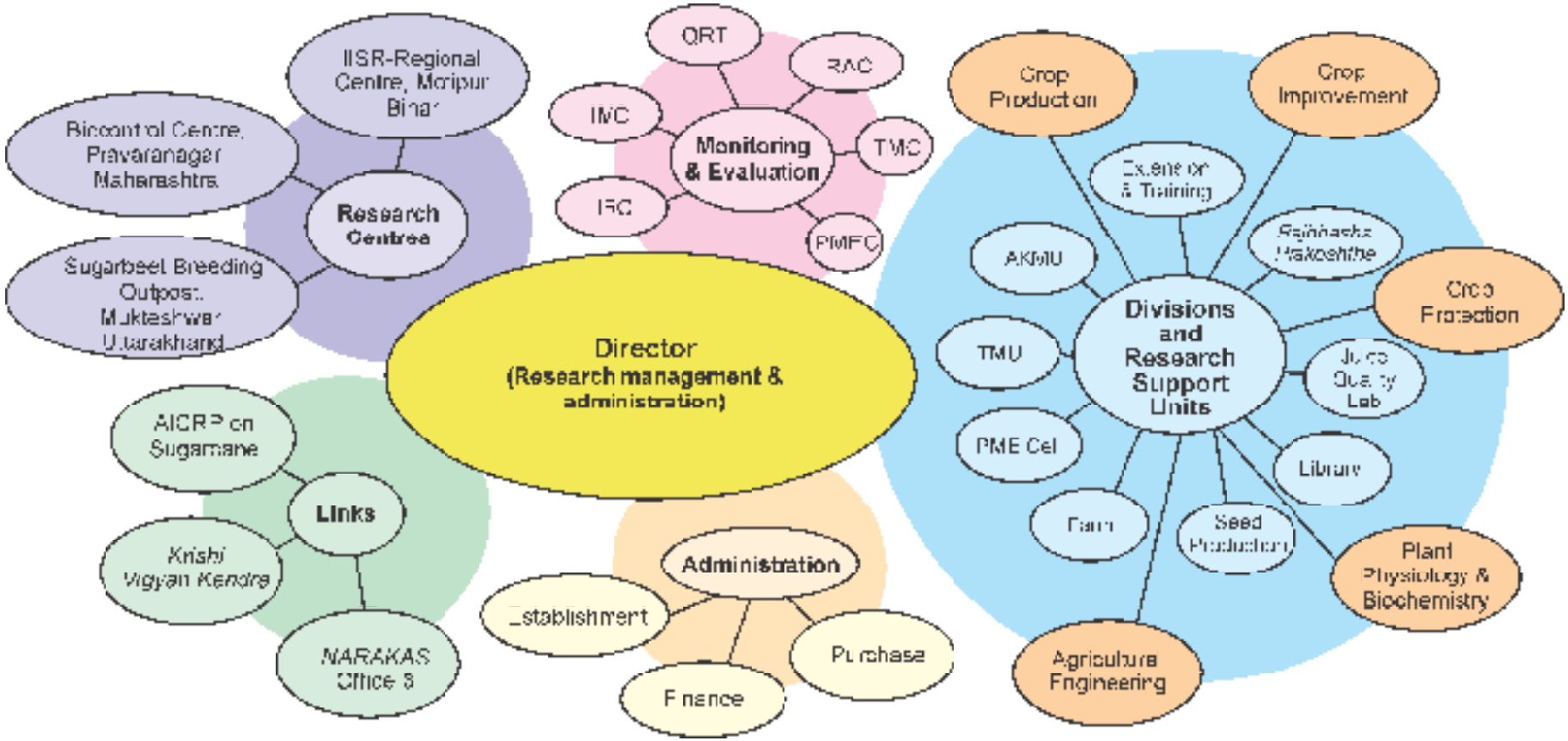
d. Reducing cost of pesticide use in an eco-friendly manner through bio-intensive IPM and IDM

e. Mechanizing sugarcane farming

Arresting decline in factor productivity

a. Soil biological and nutritional dynamism

b. Carbon sequestering through cropping system



Organizational Structure

Financial statement (2016-2017)

Particulars	Non-Plan (₹ in lakh)		Plan (₹ in lakh)	
	Revised Estimate	Expenditure	Revised Estimate	Expenditure
ICAR-Indian Institute of Sugarcane Research	4893.00	4687.96	260.00	260.00
All India Coordinated Research Project on Sugarcane	-	-	668.65	667.89

Staff position as on March 31, 2017

Category	Sanctioned	Filled	Vacant/Surplus
Research Management Position	1	1	0
Scientific			
Principal Scientist	8	5	3
Senior Scientist	15	16	+1
Scientist	50	35	15
Total	74	57	17
Technical			
Cat. I (T-1)	77	59	18
Cat. II (T-3)	54	38	16
Cat. III (T-6)	3	3	0
Total	134	100	34
Administrative	49	45	4
Skilled Supporting Staff	72	20	52
Total	329	222	107

CHAPTER 1

Genetic Improvement of Sugarcane for High Cane and Sugar Productivity

Sugarcane variety identified for cultivation

CoLk 09204 (Ikshu-3) (parentage, CoLk 8102 x CoJ 64) a mid-late maturing sugarcane variety has been identified in AICRP(S) Biennial Workshop at VSI, Pune for cultivation in North West Zone. The additional strength of CoLk 09204 lies in its good ratoonability. Some key features and other attributes of CoLk 09204 are given in Fig. 1.1 and Table 1.1.

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

Parentage	Cane yield (t/ha)	CCS (t/ha)	Sucrose (%) at 12 month	Pol % cane at 12 month
CoLk 8102 × CoJ 64	82.8	9.3	17.0	13.2

Fig. 1.1. Some key characteristics of sugarcane variety CoLk 09204

Sugarcane clones accepted for multi-location evaluations under AICRP on Sugarcane

Two early (CoLk 16201 and CoLk 16202) and two mid-late (CoLk 16203 and CoLk 16204) maturity group clones were accepted for multi-location testing in the North-West Zone (Table 1.2). Three early (CoLk 16466, CoLk 16467 and CoLk 16468) and three mid-late (CoLk 16469, CoLk 16470 and CoLk 16471) maturity group clones were accepted for the North Central Zone during AICRP(S) Group Meeting held at Vasantdada Sugar Institute, Pune during Nov. 2016.

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

A collection of 339 genotypes consisting of *Saccharum officinarum*, *S. barberi*, *S. sinense*, ISH clones, Ikshu ISH clones, LG selections, commercial hybrids, and somaclonal variants (25) was maintained. It includes 162 commercial hybrids, 51 ISH & Ikshu ISH lines, 71 LG clones and 30 species level genotypes.

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

Technology Development: Two clones, viz., LG 10803 (BO 91 × Co 62198) and LG 11819 (BO 91 × Co 62198) having MR reaction to red rot pathotypes Cf 01, Cf 08 and Cf 09 with >17% sucrose were proposed in AICRP(S) for multi-location evaluation (Table 1.3).

Inclusion of genotypes in the station trial: Three promising clones, viz., LG 10805 (BO 91 × Co 62198), LG 11816 (BO 91 × Co 62198) and LG 11842 (CoS 767 × BO 91) having resistance to red rot pathotype Cf 08 and >18% sucrose were promoted to station trial (2017-18). These clones gave >88 t/ha cane yield.

Table 1.2. List of sugarcane clones accepted for evaluation in Zonal Varietal Trials under AICRP(S)

Clone	Maturity group	Parentage	CCS (t/ha)	Cane yield (t/ha)	CCS (%)	Sucrose (%)
North West Zone						
1. CoLk 16201 (LG 11001)	Early	87A298 × CoSe 92423	10.13	81.4	12.44	17.98
2. CoLk 16202 (LG 09487)	Early	LG 95053 × CoLk 94184	9.83	78.8	12.48	18.04
3. CoLk 16203 (LG 09110)	Mid-late	CoLk 7901 GC	11.10	84.9	13.08	18.71
4. CoLk 16204 (LG 11663)	Mid-late	Co 1158 × CoLk 8002	10.21	77.4	13.19	18.92
North Central Zone						
1. CoLk 16466 (LG 09707)	Early	BO 91 × Co 86002	10.39	84.67	12.27	17.89
2. CoLk 16467 (LG 08749)	Early	Co 98010 × CoPant 97222	10.71	88.65	12.08	17.46
3. CoLk 16468 (LG 11706)	Early	BO 146 GC	10.65	90.45	11.88	16.98
4. CoLk 16469 (LG 10717)	Mid late	CoJ 83 × CoPant 97222	10.91	88.45	12.33	17.98
5. CoLk 16470 (LG 10726)	Mid late	CoS 8436 × CoSe 92423	11.34	92.50	12.26	17.84
6. CoLk 16471 (LG 07776)	Mid late	CoH 56 GC	10.62	87.25	12.18	17.60

Evaluation and selection of clones having red rot resistance in three clonal generations

Based on the agronomic characters, HR Brix (%) and sucrose (%), 16 clones from different crosses of C_2 generation were selected. These clones had sucrose content ranging from 16.89% (LG 13808) to 20.7% (LG 13803) at 12 month maturity. Genotypes, LG 13809 (CoLk 8102 × BO 91), LG 13827 (Co 86002 × ISH 147), LG 13828 (Co 86002 × ISH 147) and two clones, LG 13843 and LG 13844 of cross BO 91 × Co 62198 having >18% sucrose were found to be agronomically promising. Six clones exhibited moderately resistant reaction to both the red rot pathotypes Cf 08 and Cf 09 in third clonal generation (Table 1.4). Four clones, viz., LG 12809, LG 12825, LG 12826 and LG 12829 recorded >16.9% sucrose and MR reaction to red rot pathotypes Cf 08 and Cf 09.

Evaluation of advance generation clones in plant and ratoon: A trial comprised of 11 clones and three check varieties (Co 0238, CoJ 64 and CoS 767) was conducted in CRBD to evaluate their yield and quality performance.

Table 1.3. Reaction to red rot pathotypes (Cf 01, Cf 08 and Cf 09)

Clone	Parentage	NMC (000/ha)	CCS yield (t/ha)	Cane yield (t/ha)	Sucrose (%)	SCW (kg)	Reaction to red rot		
							Cf 01	Cf 08	Cf 09
LG 10803	BO 91 × Co 62198	136.17	11.30	83.7	19.37	0.70	MR	MR	MR
LG 10805	BO 91 × Co 62198	127.97	10.79	88.81	17.68	0.72	NR	MR	MR
LG 10807	BO 91 × Co 62198	119.60	08.42	66.56	18.15	0.70	MR	MR	S
LG 11816	BO 91 × Co 62198	141.41	11.37	90.15	18.14	0.64	-	MR	-
LG 11821	BO 91 × Co 62198	138.96	11.61	88.81	18.76	0.70	MR	MR	MR
LG 11842	CoS 767 × BO 91	142.47	11.54	90.25	18.43	0.67	MR	MR	MR
LG 12825	ISH 100 × CoSe 92423	120.63	07.53	66.22	16.62	0.56	-	MR	MR
LG 12859	ISH 150 Self	142.33	06.82	58.10	16.96	0.45	MR	MR	MS
LG 12854	CoLk 8002 GC	135.07	06.19	56.73	15.97	0.54	MS	MS	S
LG 12853	BO 91 GC	126.17	07.93	72.61	16.29	0.61	MR	MR	-
LG 12850	Co 1148 × BO 91	112.48	5.07	47.39	15.86	0.46	MR	MS	HS
CoJ 64		82.96	6.72	49.73	19.38	0.60	S	S	S
CoS 767		97.57	6.55	55.57	17.10	0.59	MS	S	S
Co 0238		82.56	10.8	74.27	20.75	0.93	MS	MR	MR
CD (0.05)		6.37		5.30	0.93	0.02			
CV (%)		3.11		4.48	3.11	1.93			

MR = Moderately resistant, S : Susceptible, MS : Moderately susceptible, HS : Highly susceptible

Table 1.4. Reaction against red rot pathotypes (Cf 08, Cf 09) and HR brix in third clonal generation (C_3)

Clone	Parentage	Sucrose (%)	Reaction to red rot	
			Cf 08	Cf 09
LG 12805	BO 91 × CoLk 97050	18.6	MR	-
LG 12809	CoS 8436 × ISH 147	17.4	MR	MR
LG 12824	ISH 100 × CoSe 92423	18.13	MR	MR
LG 12825	ISH 100 × CoSe 92423	16.94	MR	-
LG 12826	ISH 100 × CoSe 92423	18.10	MR	MS
LG 12829	ISH 100 × CoSe 92423	18.10	MR	NR
LG 12850	Co 1148 × BO 91	20.4	MS	HS
LG 12853	BO 91 GC	18.2	MR	-
LG 12854	CoLk 8002 GC	18.6	MS	S
LG 05823		16.4	MR	-

MR: Moderately resistant, MS: Moderately susceptible, MS: Highly susceptible, S: Susceptible

Four clones, LG 10803, LG 10805, LG 11821 and LG 11842 exhibited moderately resistant (MR) reaction to red rot pathotypes, Cf 08 and Cf 09 (Table 1.3). Clone LG 11842 exhibited the highest cane yield (90.25 t/ha) followed by LG 11816 (90.15 t/ha), LG 10805 (88.81 t/ha), LG 11821 (88.81 t/ha) and LG 10803 (83.7 t/ha) over the best check Co 0238 (74.27 t/ha). These five clones recorded >17.68% sucrose at 12 month maturity. The highest sugar yield was recorded in LG 11821 (11.61 t/ha) followed by LG 11842 (11.54 t/ha), LG 11816 (11.37 t/ha) and LG 10803 (11.3 t/ha). The clone LG 10803 also performed well in station trials during 2016-17.

Development of top borer tolerant genetic stocks of sugarcane

Out of the 24 sugarcane genotypes tested, 17 recorded higher cane weight compared to the check variety. Incidence of top borer in III and IV brood was recorded. Genotypes, CoLk 13202, C-1-10, D-1-3, D-5-10, D-1-10, CoLk 8102, B-2-3, A-5-3, CoJ 64, LG 11602, LG 11604, LG 07602 and LG 07201 recorded 10.19-16.67% incidence of top borer (III brood), while, LG 11601, LG 07603 and LG 07605 showed 25.8, 40.0 and 28.02% incidence, respectively. In the genotype CoLk 13201, no incidence of top borer (III brood) was recorded, but a low incidence (8.88%) of IV brood top borer was recorded. Rest of the genotypes recorded <10% incidence of top borer (III brood).

Development of sugarcane varieties for sub-tropics

Hybridization and seedling raising: A total of 30 bi-parental crosses and 12 GCs were attempted at NHG, SBI, Coimbatore during Oct.-Nov. 2016. In addition, fluff of five poly-crosses were also received for evaluation.

Multiplication of promising clones: Twenty eight advanced sugarcane clones with good quality characters suitable for further evaluation under early and mid-late groups were multiplied and evaluated for juice quality between Nov. and Feb. Twelve better performing clones with good juice quality were selected for further multiplication during 2017-18 (Table 1.5). Of these, six clones were proposed for evaluation in Station Trial.

Table 1.5. Sucrose content of some promising clones at different months

Clone	Sucrose content (%)		
	November	January	February
LG 11091	16.07	18.16	
LG 11212	17.78	20.48	
LG 12007	16.59	18.96	
LG 12028			18.77
LG 12035			19.97
LG 12038			18.9
LG 12042	17.11	19.66	
LG 12081	17.77	19.76	
LG 13001			20.63
LG 13002			20.91
LG 13009	16.9	21.08	
LG 13030		18.94	
CoJ 64	17.61	19.05	
CoPant 97222	13.58	19.65	

Evaluation of ratoon of advanced PVT clones: An experiment was conducted with 18 advanced clones and two early standards, CoJ 64 and Co 0238 in three replications. CCS (t/ha) was significantly higher for LG 11705 followed by LG 11704 and LG 11001 over the best check Co 0238. At 8 month crop age, LG 09743 was numerically superior to the best check (CoJ 64), while at 10 month, genotypes LG 09120, LG 09119, LG 11705

and LG 09743 were found superior to the checks.

Evaluation of advanced clones for juice quality: Two sets of material were planted in field for assessment of juice quality before proposing for Station Trial. First set comprising of 14 genotypes (advanced clone and released varieties) along with four standards (CoJ 64, Co 0238, CoS 767 and CoPant 97222) was planted in spring season. Second set comprising 16 advanced clones with two standards (CoJ 64 and Co 0238) was planted in autumn season. None of the clones from both the sets was found superior in terms of juice quality.

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

Technology development: Six sugarcane clones comprising of three early (CoLk 16466, CoLk 16467 and CoLk 16468) and three mid-late group (CoLk 16469, CoLk 16470 and CoLk 16471) were accepted during AICRP(S) Workshop for their evaluation under multi-location trials of the North Central Zone.

Evaluation of elite clones: Twenty three elite sugarcane clones were evaluated for their growth performance and quality parameters under target environment. In addition, 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) selected under Lucknow conditions were sent to IISR-RC, Motipur for their evaluation.

Seedling raising and selection: A total of 5912 seedlings, raised from 24 bi-parental sugarcane crosses developed during crossing season 2014, were ratooned for their evaluation under target conditions. Out of that, 165 C_1 clones were selected based on HR brix and growth performance (Table 1.6). These selected clones have been planted for their further evaluation under target environments.

Hybridization and seedling raisings: Bi-parental crosses and GCs were attempted at NHG, ICAR-SBI, Coimbatore during Oct.-Nov. 2016. Seedlings grown in the glass house from the fluff of 2015 crossing year were transplanted in the field and their growth was observed.

Evaluation of mid-late maturing sugarcane clones of North West Zone

Performance of IISR entries in multi-location trials under AICRP(s)

Initial Varietal Trial (Mid-late): Two entries (CoLk 13204, CoLk 13205) of IISR were evaluated along with 11 other entries (Co 13035, Co 13036, CoH 13261, CoH 13262, CoH 13263, CoPant 13223, CoPant 13224, CoPb

Table 1.6. Cross-wise seedlings raised and transplanted

Sr. No.	Cross	Number of seedlings	Number of clones selected (>20% HR Brix in Oct.)	Sr. No.	Cross	Number of seedlings	Number of clones selected (>20% HR Brix in Oct.)
1.	Co 1158 × Co 62198	536	9	13.	CoSe 95422 × Co 62198	464	29
2.	CoS 8436 × Co 0233	224	3	14.	BO 91 × Co 62198	192	9
3.	CoLk 7901 × ISH 176	224	3	15.	LG 06810 × CoSe 92423	64	1
4.	CoSe 95422 × CoS 8436	840	12	16.	CoLk 94184 × BO 91	72	9
5.	LG 05460 × CoSe 92423	568	24	17.	Co 0233 × CoS 8436	32	0
6.	CoP 06436 × BO 130	232	5	18.	CoLk 8102 × Co 62198	24	3
7.	CoS 8436 × Co 1148	288	8	19.	CoS 96268 × ISH 287	16	0
8.	BO 91 × CoH 15	1080	12	20.	BO 92 × Co 86249	16	0
9.	UP 9530 × CoP 9301	144	5	21.	Co 98014 × Co 86249	8	0
10.	CoJ 80 × Co 86011	48	2	22.	CoLk 8102 × BO 130	8	0
11.	BO 97 × BO 32	184	11	23.	CoSe 96436 × Co 0233	216	6
12.	BO 97 × Co 775	176	0	24.	CoP 06436 × CoPant 97222	256	14
	Total					**5912**	**165**

13182, CoPb 13183, CoS 13232, CoS 13233) and three standards (CoS 767, CoS 8436, CoPant 97222) for yield and quality parameters. The entry CoLk 13205 was at second rank (90.81 t/ha) after CoPb 13182 (94.78 t/ha). While for CCS yield, CoLk 13204 recorded third rank (10.30 t/ha) after the entries Co 13035 (11.33 t/ha) and CoH 13261 (11.18 t/ha). CoS 767 recorded a CCS yield of 8.21 t/ha.

Advanced Varietal Trial (Mid-late) Ist Plant: The IISR entry, CoLk 12205 was evaluated along with five other entries (Co 12029, CoH 12263, CoPant 12226, CoPb 12211, CoS 12232) and three standard varieties (CoS 767, CoS 8436, CoPant 97222). CoLk 12205 recorded the highest cane yield (94.70 t/ha) which was significantly superior to the best check CoS 767 (73.58 t/ha).

Advanced Varietal Trial (Mid-late) IInd Plant: Two entries of IISR (CoLk 11204, CoLk 11206) were evaluated along with four other entries (Co 11027, CoH 11263, CoPb 11214, CoS 11232), and three standard varieties (CoS 767, CoS 8436, CoPant 97222). The entry, CoLk 11206 recorded the highest cane yield (96.3 t/ha) as well as the highest CCS yield (12.14 t/ha).

Advanced Varietal Trial (Mid-late) Ratoon: Two entries of IISR (CoLk 11204, CoLk 11206) were evaluated along with four other entries (Co 11027, CoH 11263, CoPb 11214, CoS 11232), and three standards (CoS 767, CoS 8436, CoPant 97222). The entry CoLk 11206 recorded the highest (97.21 t/ha) cane yield and CCS yield (11.74 t/ha).

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

Chromosome number variability studies on a sugarcane variety CoLk 8102 and its **clonal** population CoLk 8102 GC revealed that the modal chromosome number of CoLk 8102 was 2n=ca. 108. In the progeny population, the modal chromosome numbers/cell ranged from 92-112 this year. Analysis of this somatic chromosome number study in third consecutive clonal generation of CoLk 8102 GC *vis-à-vis* previous generations revealed that the range of chromosome number variation has narrowed down gradually which indicates a trend towards stabilization of chromosome number in progeny plants.

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

Isolation of disease resistance gene analogs (RGAs) using the conserved motifs of the resistance genes was continued using homology-based PCR to target the nucleotide binding site (NBS) conserved regions from sugarcane. Fifty five combinations of degenerate primers designed from the nucleotide binding sites (NBSs)-type sequences containing highly conserved motifs of P-loop, kinase-2, kinase-3a, and GLPL domains were used for amplification of resistance gene candidates (RGCs) from genomic DNA of sugarcane genotypes resistant or susceptible to red rot. Thirty five primer pairs yielded successful amplification and six amplicons were resolved for each primer. The clear amplicons were sequenced which were subjected to BLASTn homology search. Of more than hundred sequences analyzed, 38 showed the characteristic features of known R-genes such as NBS/LRR resistance protein-like gene sequences of *Saccharum* hybrid cultivars, *Sorghum bicolor*, *Zea mays*, *Triticum aestivum* and *Aegilops tauschii*, putative disease resistance protein mRNA of *Oryza sativa Japonica* Group, putative disease resistance RPP13-like protein of *Setaria italica* and *Elaeis guineensis*. The sequence comparisons of these putative RGAs with known reference sequences from plant species available in NCBI database revealed considerable variability in the putative RGAs amplified in this study.

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

This study was initiated to unravel the conserved and novel miRNA profiles in response to red rot infection and their role in understanding small RNA-guided genes controlling red rot resistance in sugarcane. One red rot resistant genotype (BO 91) and one susceptible genotype (CoJ 64) was inoculated with *C. falcatum* pathotypes (Cf 08 and Cf 09), and stalk samples from inoculated and non-inoculated (control) plants were withdrawn at different time intervals.

Mapping of loci linked to sugar content in sugarcane

This study relates to identify molecular markers and mapping of loci linked to sugar content in sugarcane. Phenotyping of the segregating population from bi-parental and selfed population was done for initial growth parameters and HR Brix (in Oct.). In a 12 month old population of CoLk 7901 (selfed), ~60% of the clones exhibited a mean pol % juice values as 14-18%, 7% had in the range of 9-13%; 20% expressed pol % juice >18% and 22 genotypes exhibited pol% juice values of 19-21%. Three of the clones (E-42, E-150, E-246) had >20% sucrose. Genotyping of the segregating populations was continued for mapping studies using 25 primer pairs, of which 20% yielded polymorphic products.

Sugarcane clones in different generations were also evaluated to identify high sugar genetic stocks. Based on HR Brix, 292 selections were advanced to C_1 generation. Similarly, 94 high sugar genotypes from C_1 generation were selected and advanced to C_2 generation. Thirty three genotypes in the C_2 generation exhibited Pol % juice values of 17-20%. Out of 44 entries in a replicated trial planted in the field during 2015-16, 8 promising genotypes were selected for further evaluation and their response to red rot pathogen (Table 1.7). Two genotypes, LG 11517 and LG 11511 were advanced for evaluation in the divisional station trial and three high sugar genetic stocks, LG 08443, LG 09487 and LG 11001 were sent to NHG, ICAR-SBI, Coimbatore.

Table 1.7. Performance of a few promising genotypes in replicated trial

Genotype	Corrected Brix%	Sucrose (%)	Purity (%)	CCS (%)
LG 11543	21.78	19.58	87.55	13.65
LG 11459	22.40	20.04	88.52	13.94
LG 11517	20.28	17.61	86.80	12.08
LG 12429	21.26	18.62	87.56	12.82
LG 11511	20.15	17.35	86.05	11.84
LG 11528	21.48	18.81	87.65	12.95
LG 11506	20.57	18.24	88.66	12.64
LG 12426	20.32	17.84	87.85	12.30
LG 12419	20.47	17.79	85.69	12.20
LG 12453	20.14	17.47	86.75	11.97
LG 12414	20.18	17.48	86.66	11.97
GM#	19.15	16.57	86.37	11.34
SED#	0.70	0.87	2.10	0.70
CD 5%#	1.44	1.79	4.32	1.44
CV%#	4.47	6.42	2.98	7.59

#These values are based on data of 44 genotypes tested in the replicated trial.

Identification of marker-trait associations for morphological descriptors and yield component traits in sugarcane

The genome complexity of sugarcane coupled with complicated genetic mechanism controlling yield and quality traits increases manifolds the hurdles in targeted breeding of this polyaneuploid crop. Hence, stable marker-trait associations (MTAs) could be of practical use for breeding and selection in sugarcane. In this pursuit, ninety two sugarcane varieties from sub-tropical India were subjected to molecular profiling with 174 simple sequence repeat markers and characterized for 23 qualitative (morphological descriptors) and nine quantitative traits that directly or indirectly contribute to yield and juice quality. Using STRUCTURE-based population stratification study and a mixed linear model (MLM) for MTA analysis, a total of 60 MTAs were identified for 22 qualitative traits that were able to explain a significantly higher (up to 40%) proportion of the phenotypic variations compared to all the previous reports of MTA studies in sugarcane (Table 1.8, Fig. 1.2, 1.3 and 1.4). In addition, 21 MTAs stable over the three years of study were also identified for nine quantitative traits that explained 16-37% of the total trait variation. It could be concluded that the qualitative traits that are governed mostly by one or a few genes are more responsive to MTA studies and hence, have a better potential to be adopted in marker-assisted breeding programmes in sugarcane.

Fig. 1.2. The markers IISR_322_190 (R^2 value 0.19) was identified to be associated with growth crack

Table 1.8. Significant marker-trait associations (MTAs) identified in sugarcane

Trait	Associated marker
Corrected Brix	IISR_236_590
Commercial cane sugar	IISR_236_590, IISR_88a_300
Fibre content	ESTB157_600
Internode diameter	IISR_317_110, IISR_48_175 , IISR_48_1000
Leaf blade width	IISR_140_180, ESTB145_400
Number of millable canes	SEGMS73113a_70, ESTA48_260 IISR_176c_280
Plant height	IISR_279_1100, IISR_308_250
Sucrose content	IISR_236_590, IISR_114_150, IISR_88a_300
Growth crack	IISR_322_190
Bud cushion	IISR_48_175

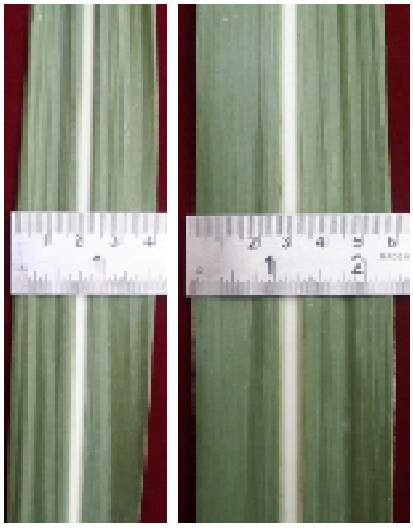


Fig. 1.3. The markers IISR_140_180 (R^2 value 0.19), ESTB145_400 (R^2 value0.16) were identified to be associated with leaf blade width

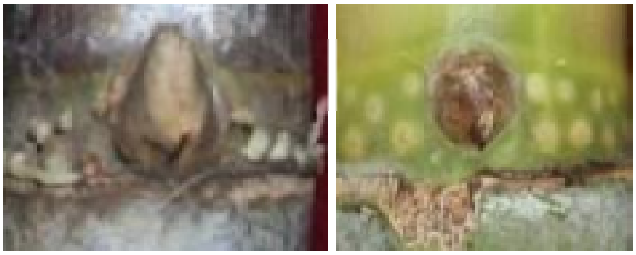


Fig. 1.4. The markers IISR_48_175 (R^2 value 0.29) was identified to be associated with bud cushion trait

Identification of putative candidate genes and validation of molecular markers for red rot resistance in sugarcane

Using a panel of 119 sugarcane genotypes fingerprinted for 944 SSR alleles, four marker-trait associations (MTAs) for resistance to red rot were identified. These MTAs were able to explain 10-16% of the trait variation, individually, and of these four MTAs, EST sequences diagnostic of three could be BLAST searched to the sorghum genome with significant sequence homology. The EST sequence of markers IISR_298a_140 and IISR_256_240 (associated with race Cf 01) aligned on sorghum chromosome 7 and chromosome 2, respectively. The EST sequence of IISR_46b_170 (associated with Cf 09) showed similarity with a sequence located on sorghum chromosome 2. The amino acid sequences predicted from gene models of genes located in the region flanking MTAs for red rot resistance were used and several genes encoding proteins involved in pathogen resistance, *e.g.*, cytochrome P450, glycerol-3-phosphate transporter-1, MAP kinase-4, serine/threonine-protein kinase, ring finger domain protein and others were identified that were localized to the vicinity of these MTAs.

For validation of identified markers, twenty primer pairs were designed using the sequence of putative candidate genes which were identified in vicinity of MTAs for red rot resistance. For this, a panel of six sugarcane genotypes, including three resistant (BO 91, SES 594, CoLk 94184) and three susceptible (CoS 767, CoJ 64 and Co 1148) genotypes for red rot reaction were used. The genomic DNA from all the six genotypes were amplified using twenty primers pairs (CGP1-CGP20), of which, ten primers gave successful amplification in all the genotypes. One primer pair (256_C2_G39-2) produced an amplification product of ~800 bp in all the resistant genotypes but not in susceptible ones (Fig. 1.5).

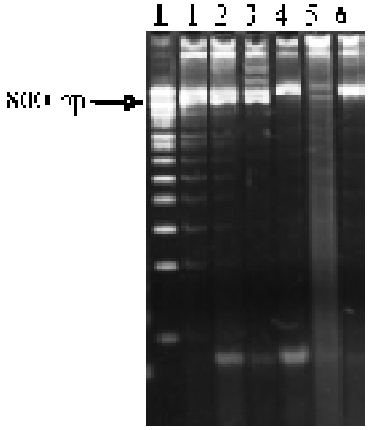


Fig. 1.5. Amplification of ~800 bp product in red rot resistant genotypes (lanes 1-3) by the primer pair 256_C2_G39-2. Lanes; L: DNA size marker; 1: BO 91; 2: SES 594; 3: CoLk 94184; 4: CoS767; 5: CoJ 64; 6: Co 1148

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

Rapid *in vitro* clonal propagation of sugarcane genotypes, CoLk 9709, CoLk 09202, Co 05011, Co 06034, Co 0238 was achieved 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. Cent percent shoot regeneration frequency was obtained on MS medium supplemented with 2.22 µM BA +2.3 µM Kin + 26.8 µM naphthalene acetic acid (NAA) + 3% sucrose. Vigorous rooting was obtained on MS medium containing 26.8 µM NAA and 5% sucrose. Plantlets were acclimatized in soil, sand and compost (1:1:1) for about 3 weeks and thereafter, transferred to open field (with >95% survival) where plantlets grew vigorously. In this way, more than 10,000 plantlets of varieties CoLk 9709, CoLk 09202, Co 05011, Co 06034 and Co 0238 were transferred to field. C_1 plants derived from tissue culture were planted in field along with the 3-bud sett of same variety to evaluate the comparative performance.

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

In vitro preservation of sugarcane germplasm using slow-growth culture technique is being explored. The shoot-tip explants of sugarcane genotype Khakai were established and multiplied on MS medium with 2.22 µM BA, 0.5 µM Kinetin, 0.5µM GA_3. Treatment of cultures with high osmoticum (0-10% sucrose in the medium; Fig. 1.6), two temperature regime (8^0C and 25^0C) and semi-solid and liquid medium is under progress. The shoots cultured on MS medium with 2.22 µM BA, 0.5 µM Kinetin, 0.5µM GA_3 and supplemented with 10% sucrose were able to survive for 365 days without any subculturing. Genetic fidelity assay using ISSR markers revealed no genetic variation in the recovered cultures.

a b c d

Fig. 1.6. *In vitro* cultures of sugarcane (genotype Khakai) maintained at 25^0C after 365 days of incubation on MS medium supplemented with 2% (a), 3% (b), 5% (c), and 10% sucrose (d)

Accredited test laboratory under National certification system for tissue culture-raised plants (DBT, New Delhi)

During 2016-17, a total of 480 representative samples of sugarcane and 320 of banana from 8.0 lakh tissue culture plantlets produced in DBT recognized tissue culture production units were tested for virus indexing and genetic fidelity for batch certification. Similarly, 170 samples of sugarcane [for Sugarcane mosaic virus (SCMV), Sugarcane yellow leaf virus (SCYLV), Sugarcane bacilliform virus (SCBV), and phytoplasma] and 915 samples of banana [Banana bract mosaic virus (BBrMv), Cucumber mosaic virus (CMV), Banana bunchy top virus (BBTV), and Banana streak virus (BSV)] were tested for virus indexing of initial mother culture and test reports were submitted to DBT.

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

This study is based on an F_1 mapping population developed using two sugarcane lines MS 68/47 and CoV92102 that have contrasting sucrose content. A total of 262 F_1 (MS 68/47 × CoV 92102) plants were maintained. Phenotyping of two parents and 262 F_1s for TSS, NMCs, leaf width and cane diameter and cane length revealed that the parental lines of the mapping population have contrasting tillering habit. Total RNA was extracted and RNA sequencing libraries of two parents and two extreme bulks were prepared and sequenced using paired-end chemistry on Illumina platform (Table 1.9). The *de novo* sequence assembly and functional annotation is under progress.

Table 1.9 Statistics of raw reads generated from four transcriptome libraries

Sample	Total paired-end reads	Total data (Giga Bytes)
MS 68/47 (Parent)	43529419	12.63
CoV 92102 (Parent)	53013554	15.33
BH (High sucrose bulk)	52381343	15.31
BL (Low sucrose bulk)	46015104	13.26

National project on transgenic crops (Herbicide tolerant sugarcane)

Direct regeneration protocol was standardized (varieties Co 0238, Co 5011, CoLk 9709, CoLk 94184) using media combination MS medium + 5.0 mg/l NAA + 0.5 mg/l Kinetin which gave 70-80% regeneration frequency. Shoots were transferred to the rooting media and the plantlets so developed were transferred to the pot (1:1:1; sand:soil:FYM) then to field after acclimatization (Fig. 1.7).

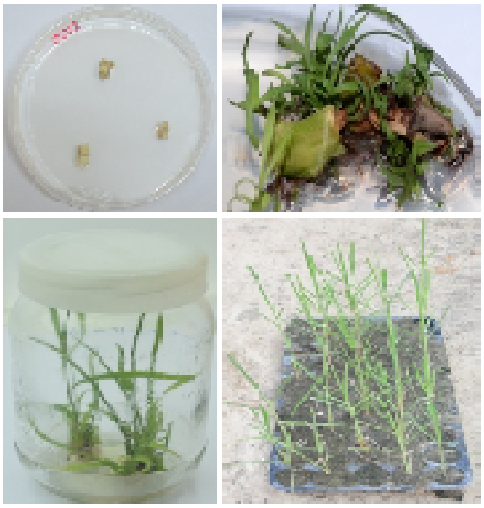
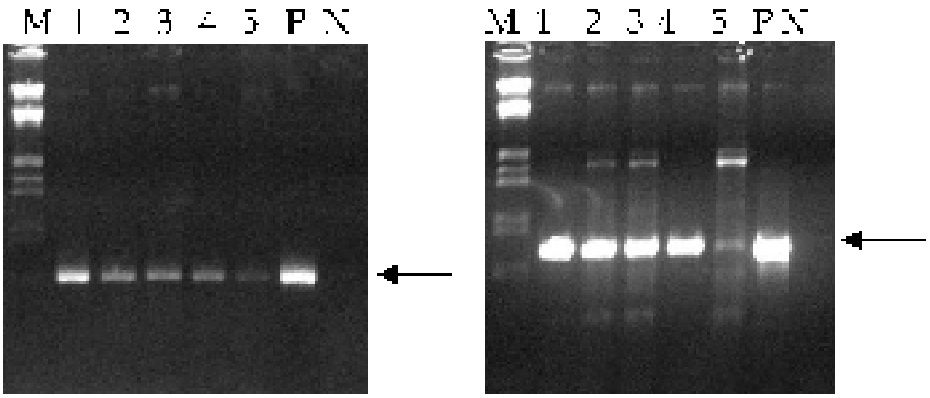


Fig. 1.7. Various stages of regeneration from leaf explant and plantlet development in sugarcane variety Co 0238



A B

Fig.1.8 PCR with *npt*II gene-specific primer showing amplification of ~500 bp product (A), and with gus gene specific primer showing amplification of ~750 by product (B). Lanes; M: DNA size marker (ë DNA-*Hind*III + *Eco*RI double digest); 1-5 putative transformants; P: Positive control; N: non-transformed tissue. The arrow indicates ~750 bp product specific to *gus* reporter gene

The genetic transformation parameters in the sugarcane variety Co 0238 was established using *A. tumefaciens* strain LBA4404 containing the binary vector pCAMBIA 2301 habouring *npt*II and *gus* reporter genes. Leaf roll explants were tested for transient GUS expression. Putative transformants were screened using PCR with for *gus* as well as *npt*II gene-specific primers (Fig. 1.8).

ICAR Seed Project: Seed production in agricultural crops

During the year 2016-17, approximately 8,000 q of seed cane of improved varieties of sugarcane was produced, out of which ~6,000 q seed cane was lifted and the rest was utilized for further multiplication and distribution to farmers.

CHAPTER 2

Natural Resource Management

Soil nutrition and health for higher tonnage and enhanced quality of the cane

Assessing nutrient interactions for sustaining sugarcane productivity and soil health

A field experiment under sugarcane ratoon crop was conducted with four levels of nitrogen (0, 100, 150 & 200 kg N/ha) and potassium (0, 30, 60 & 90 kg K_2O/ha) for assessing nitrogen and potassium nutrient interaction effect in randomized block design (Factorial) with three replications. The nutrient treatments under first ratoon crop were imposed in the same plot of the same treatment of plant crop treatments. The initial soil status before planting was low in soil organic carbon and nitrogen, whereas, available phosphorus and potassium were in medium range. The soil pH was 8.78 and neutral in soil salinity. The significant nutrient interaction effect of nitrogen and potassium was not found on sugarcane ratoon crop yield, yield attributes and juice quality parameters. However, both the nutrients individually influenced the cane yield and yield attributes. The significantly higher cane yield (62.8 t/ha), NMC (144.4 thousand/ha), single cane weight (526 g) and plant height (198.0 cm) were recorded at the nitrogen level of 200 kg/ha, whereas, cane yield (58.2 t/ha), NMC (137.3 thousand/ha), single cane weight (515 g) and plant height (186.8 cm) were recorded at 90 kg K_2O/ha. The cane diameter and juice quality parameters viz., brix%, sucrose and purity % were significantly not affected due to varying nutrient doses of nitrogen and potassium (Table 2.1).

The second experiment was conducted for assessing phosphorus and zinc nutrient interaction. The treatments were imposed in ratoon crop of the same treatment plots of the plant crop. The four levels of phosphorus *i.e.* 0, 30, 60 & 90 kg P_2O_5/ha were imposed whereas the four levels of the zinc ($ZnSO_4.7H_2O$) *i.e.*, 0, 15, 30 & 45 kg/ha were exduded in the sugarcane ratoon crop to study the residual effect of zinc applied in the first ratoon crop. The highest cane yield (63.9 t/ha) was recorded at the phosphous level of 90 kg/ha, whereas, it was at par with cane yield of phosphorus at the level of 60 kg/ha (61.8 t/ha). The significant residual effect of zinc on cane yield was recorded upto the level of 15 kg/ha (59.2 t/ha) (Table 2.2).

Table 2.1. Effect of nitrogen and potassium on yield attributes, yield and juice quality of first sugarcane ratoon

Treatment	Cane length (cm)	Cane diameter (cm)	NMC (000/ha)	Cane wt. (g)	Cane yield (t/ha)	^{0}Brix	Sucrose (%)	Purity (%)
Nitrogen level (N kg/ha)								
0	165.4	1.89	124.4	465	45.3	20.11	18.36	87.14
100	180.2	1.91	129.9	492	52.0	20.38	18.59	87.68
150	189.6	1.95	136.6	523	58.4	20.29	18.68	88.11
200	198.0	1.95	144.4	526	62.8	20.06	18.36	87.31
SEm+	3.01	0.03	2.73	6.19	1.17	0.26	0.16	0.55
CD (P= 0.5)	8.68	NS	7.88	17.87	3.37	NS	NS	NS
Potassium level (K_2O kg/ha)								
0	175.4	1.90	127.1	475	48.8	19.81	18.25	86.92
30	184.7	1.91	133.7	502	53.5	20.70	18.68	88.42
60	186.3	1.93	137.1	514	58.0	20.22	18.43	87.39
90	186.8	1.96	137.3	515	58.2	20.10	18.63	87.52
SEm+	3.01	0.03	2.73	6.19	1.17	0.26	0.16	0.55
CD (P= 0.5)	8.68	NS	7.88	17.87	3.37	NS	NS	NS

Table 2.2. Response of sugarcane in terms of yield (t/ha) to phosphorus under different Zn levels

Nutrient level (kg/ha)	0.0 kg Zn	15.0 kg Zn	30.0 kg Zn	45.0 kg Zn	Mean
00.0 kg P_2O_5	49.4	50.6	52.4	52.5	51.2
30.0 kg P_2O_5	53.0	55.3	57.5	57.9	55.9
60.0 kg P_2O_5	58.2	64.6	62.4	61.8	61.8
90.0 kg P_2O_5	59.2	66.3	64.9	65.4	63.9
Mean	54.9	59.2	59.3	59.4	
CD (P=0.05) to compare mean values under phosphorus and zinc levels = 3.49					

Sugarcane productivity in relation to initial soil organic carbon content and nutrient management

A field experiment to assess the influence of initial soil organic carbon (SOC) content and nutrient management on sugarcane growth and yield was initiated in March 2015. During the year (2016-17), performance of first ratoon crop as influenced under various treatments was assessed. Ratoon was initiated in the end of January 2016 and harvested in December 2016. The experimental field consisted of plots (8 x 6 m) with varying initial SOC content as a result of addition variable rates of different bio-manures continuously for 10 years in a plant-ratoon system followed by a fallow year. Four initial SOC levels (0.45-0.55, 0.56-0.65, 0.66-0.75 and above 0.75%) and three nutrient management packages (recommended dose of fertilizers (RDF): 150, 60, 60 kg NPK; RDF + farmyard manure 10 t/ha; RDF + zinc sulphate 25 kg/ha + S 20 kg/ha) were evaluated in all combinations (12) following randomized block design with three replications. Farmyard manure was added in the stipulated plots at the time of ratoon initiation and mixed well. Whereas total quantity of zinc sulphate and sulphur were applied in the furrows as per the treatment. Soil and plant samples were drawn at different intervals to record soil physical, physico-chemical, microbial properties and plant biometric parameters.

Data depicted below in Table 2.3 evince that initial soil organic carbon content did not influence the initial shoot count (60 DAI) neither it was affected 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 significantly up to 0.66-0.75% SOC as compared to that with SOC 0.45-0.55%. The highest NMC (116.1 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 (83.4 t/ha) was attained with >

Table 2.3. Effect of initial soil organic carbon content (SOC) and nutrient management on growth and yield of sugarcane ratoon

Treatment	Shoot count at 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	194.6	412.0	208.2	106.1	257.1	2.29	68.4
0.56-0.65	199.1	480.0	232.1	115.3	267.8	2.48	82.9
0.66-0.75	211.4	425.9	220.4	116.1	258.5	2.34	81.0
> 0.75	195.0	429.8	219.9	114.6	262.4	2.39	83.4
SEd ±	18.9	29.7	6.9	3.6	7.7	0.07	5.7
CD (P=0.05)	NS	61.2	14.5	8.9	NS	0.15	11.9
Nutrient management							
RDF (150:60:60 kg NPK/ha)	191.4	420.8	213.3	109.1	261.0	2.38	75.5
RDF + FYM (10 t/ha)	211.1	448.6	227.1	117.9	259.3	2.33	81.2
RDF + $ZnSO_4$ 25 kg + S 20 kg/ha	197.5	441.5	220.2	112.7	264.1	2.37	80.0
SEd ±	16.3	25.7	6.0	3.3	6.6	0.06	4.9
CD (P= 0.05)	NS	NS	12.1	6.9	NS	NS	NS

0.76% that 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%) caused significant increase in cane thickness over that at 0.45-0.55% though further increase in SOC could not enhance the cane thickness.

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

Soil quality assessment under different sugarcane growing systems

For assessment of soil quality in different sugarcane growing systems in various practices of fertilizers application, ten villages (Block-Bankeganj, Mitoli, Kumbhigola and Lakhimpur, District-Lakhimpur Kheri) were selected for the collection of soil samples. Soil samples were collected at active growth stages of sugarcane in the month of September, 2016. On the basis of average mean values, soil pH was slightly lower in waterlogged conditions as compared to upland sugarcane growing system. Soil pH showed slightly lower in farmers' practice (FP) as compared to recommended dose of fertilizer (RDF). EC values were almost similar in all the system of sugarcane growing. However, soil organic carbon, available N and P were slightly lower where fertilizers doses applied as per farmers practices (FP) in all the conditions. The highest SOC, available N and K were recorded in water logged condition whereas the lowest was in sub-optimum condition under both the practices. In contrast to N and P, the highest available K was found in farmers practice in all the sugarcane growing conditions (Table 2.4). All the micronutrients showed sufficient range in different sugarcane growing system in both the practices of fertilizers application. Zinc content in soil was slightly higher in RDF as compared to FP but water logging condition exhibited the highest Zn content than that of sub-optimum and optimum conditions. However, Cu content was higher in RDF than FP but water logging condition showed lower Cu content as compared to sub-optimum and optimum conditions. Similarly, Fe and Mn content were slightly higher in RDF than FP in all the growing conditions of sugarcane. Waterlogging conditions showed the highest Fe and Mn content in sugarcane growing soils. MBC and MBN found the highest in RDF than FP. However, optimum conditions of sugarcane growing system showed the highest MBC and MBN followed by water logging condition. *Azotobacter* counts were higher in RDF as compared to FP whereas actinomycetes counts were higher in FP than RDF. Bacterial and fungal counts were higher in optimum condition followed by sub-optimal conditions (Table 2.5).

Table 2.4. Effect of sugarcane growing system on physico-chemical properties of soil in Lakhimpur Kheri district

Condition	Practices	pH (1:2.5)	EC (dSm^{-1})	SOC (%)	Available N ($kg\ ha^{-1}$)	Available P ($kg\ ha^{-1}$)	Available K ($kg\ ha^{-1}$)	Zn ($mg\ kg^{-1}$)	Cu ($mg\ kg^{-1}$)	Fe ($mg\ kg^{-1}$)	Mn ($mg\ kg^{-1}$)
Sub-optimum	FP	6.97	0.19	0.43	229.49	25.19	331.28	0.99	1.52	29.39	23.36
	RDF	7.06	0.16	0.48	236.84	31.38	372.39	0.89	1.72	32.97	22.90
Optimum	FP	6.84	0.15	0.45	240.84	33.62	379.50	1.22	1.31	32.72	20.21
	RDF	7.23	0.18	0.49	255.43	38.18	346.13	1.29	1.42	39.18	26.57
Water logging	FP	6.84	0.14	0.46	250.58	36.85	385.82	1.56	1.40	22.91	23.77
	RDF	6.91	0.20	0.49	255.73	34.24	287.20	1.69	1.53	42.19	28.46

Table 2.5. Effect of sugarcane growing system on MBC, MBN, microbial and enzymatic properties of soil in Lakhimpur Kheri district

Condition	Practices	MBC ($\mu g\ C\ g^{-1}$ soil)	MBN ($\mu g\ NH_4\text{-}N\ g^{-1}$ soil)	TCB ($\times 10^6$ cfu g^{-1} soil)	TCA ($\times 10^5$ cfu g^{-1} soil)	TCF ($\times 10^4$cfu g^{-1} soil)	AZO ($\times 10^4$cfu g^{-1} soil)	DHA (μg TFT-g^{-1} hr^{-1})	FDHA ($\mu g\ g^{-1}$ hr^{-1})	ACP (μg PNF g^{-1} hr^{-1})	ALP (μg PNF g^{-1} hr^{-1})
Sub-optimum	FP	149.50	6.59	4.94	8.08	16.67	23.96	0.61	9.30	43.45	61.88
	RDF	151.27	5.65	4.50	4.89	23.13	20.24	0.69	9.65	44.13	68.51
Optimum	FP	153.33	7.66	5.21	9.67	26.02	35.79	0.94	9.00	42.82	67.39
	RDF	169.62	8.11	5.62	6.53	31.42	18.39	0.95	11.2	46.73	73.28
Water logging	FP	142.07	6.58	4.01	10.18	13.14	31.52	0.91	10.3	39.31	64.27
	RDF	161.44	7.76	4.58	8.11	19.84	28.77	1.01	9.1	39.58	65.39

Impact of integrated application of organics and in-organics in improving soil health and sugarcane productivity

The data on second ratoon of sugarcane growth, yield and quality indicated significant variations among the treatments. Significantly the highest rate of ratoon stubble sprouts (83.6%) was observed under 20 t FYM + STRC nutrient application followed by the treatment of only organic application. The highest number of tillers (217.3 thousand/ha at 150 DAI), shoot count (235.7 thousand/ha at 210 DAI), number of millable canes (156.8 thousand/ha), cane yield (89.4 t/ha) and sugar yield (9.87 t/ha) were recorded under the treatment where application of FYM @ 20 t/ha was done along with soil test (rating chart) based inorganic fertilizer recommendations. However, it was found comparable to the treatment of FYM @ 10 t/ha along with biofertilizer and soil test basis inorganic fertilizers application. The yield attributing characters viz., cane length (223.9 cm), cane girth (2.21 cm) and weight of individual cane (0.90 kg) was recorded significantly highest with the application of FYM @ 20 t/ha along with inorganic fertilizers applied on the basis of soil test rating chart. The quality parameters viz., brix value and pol % were significantly improved with application of FYM and biofertilizers.

Carbon sequestration in sugarcane based cropping system

The experiment was laid out in RBD with eight treatments and three replications under rice-wheat and sugarcane-ratoon-wheat systems with objective to improve the total soil organic carbon build-up and sustain crop yields. Sugarcane genotypes (CoPK05191) was planted in the experiment in the last week of February 2016. The experimental soil was sandy loam with pH 7.45, organic carbon 0.41%, low in available nitrogen (269 kg/ha) and medium in available phosphorus (36 kg/ha) and available potassium (258 kg/ha), S (89 mg/kg), B (1.25 mg/kg), Cu (3.4 ppm), Zn (2.3 ppm), Mn (14 ppm) and Fe (45 ppm). The observations on soil microbial activity and soil microbial biomass carbon (SMBC) and other biological parameters were recorded before and after harvest of each crop. The rice and wheat crop yielded around 42 and 46 q /ha grain, respectively. Sugarcane yield varied from 107-110 t/ha under different cropping system. This is first year of experimentation and treatment has to be imposed just after harvesting of crop.

Crop management for enhancing cane productivity and profitability

Validation of cane node technology under farmers' field condition

Field experiments were planted in six villages with two farmers in each village in different sugar factory zones (East-Hata, Central-Biswan and West-Ramala) of Uttar Pradesh. Thus, the total number of farmers selected for the study was 12. Germination per cent of cane buds (77.61/39.63; 87.7/41.8 and 88.60/42.18%), tillers (163/151; 186 /173 and 207/203 - 000/ha) and millable canes population (111/101; 128/115 and 134/130-000/ha) recorded under cane node/conventional methods of planting in the East, Central and Western sugar factory zones, respectively. Germination, number of tillers and population of millable canes under cane node planting were higher to the tune of 51.32%, 4.86% and 7.26%, respectively as against conventional method of planting. Similar trend in respect to cane yield was also recorded. On an average, the cane yield of 95.11 t/ha obtained under cane node planting from all the three sugar factory zones was higher by 8.88% than that of conventional method of planting (89.66 t/ha). The technology of sugarcane planting by cane node method is becoming popular among sugarcane farmers in the state since it gives not only good cane yield but also saves precious seed cane planting material. Farmers are also preferring this technology for rapid multiplication of newly released varieties of sugarcane.

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

The yield of sugarcane under sole as well as in intercropping system varies from 90.3 to 92.2 t/ha. The intercropping of different cucurbits viz., Bitter gourd, Bottle gourd, Sponge gourd, Pumpkin, Cucumber and Ladies finger was done in sugarcane. Among the different intercrops, only Ladies finger was found the most suitable and produced about 6.0 q fruit with a gross return of ₹ 18,564 from 0.06 ha area. Under autumn planted sugarcane crop, vegetable pea and potato was intercropped. The net income from potato and pea was ₹ 12,000 and ₹ 7,500, respectively. However, from bee-keeping enterprise about 6.1 kg of the honey was produced. Banana, Papaya and *Karounda* plantation was done as per the technical programme. During summer season, sunflower was sown to facilitate the honey bee. The experiment is progressing well and observations (on different components) are under progress.

Sustainable water uses through tillage, planting system, companion cropping, and other profitable crop husbandry practices

Optimization of fertigation schedule for sugarcane through micro-irrigation technique under different agro-climatic conditions

Fourth ratoon crop was initiated during the last week of February 2016 and the crop was harvested in the second week of February 2017. It was observed that irrigation treatments significantly influenced shoot count. Length of sugarcane plant leaf at onset of monsoon was significantly influenced by both irrigation and nitrogen treatments. Number of leaves per plant were influenced significantly by nitrogen doses. However, the effect of irrigation treatments on number of leaves was non-significant. Leaf area per plant was significantly influenced by irrigation and nitrogen treatments both. Drip fertigation resulted higher leaf area index. The highest LAI (11.7) was observed when the crop was drip fertigated with irrigation water equal to 1.25 times pan evaporation and nitrogen equal to the recommended dose. Sucrose content of juice was significantly influenced by irrigation treatments. Number of millable canes were significantly affected by irrigation as well as nitrogen treatments. Interaction effect of irrigation and nitrogen on number of millable canes was also significant. Cane diameter and length were significantly influenced by irrigation treatments. However, sugarcane stalk length was also significantly influenced by nitrogen treatments. The highest sugarcane yield of 94.43 t/ha was observed in drip fertigation treatment with irrigation water equal to 1.25 times pan evaporation and nitrogen equal to 100% of recommended dose. The lowest sugarcane yield (51.53 t/ha) was observed when the crop was irrigated with surface irrigation method and 50% of recommended dose of nitrogen was applied. Drip fertigation influenced irrigation water use efficiency (IWUE) significantly. The highest IWUE of 2090.7 kg/ha-cm was recorded when sugarcane was irrigated with irrigation water equal to 0.75 times pan evaporation and nitrogen equal to 75% of recommended dose. However, surface irrigation resulted in the lowest IWUE (585.5 kg/ha-cm) when sugarcane was irrigated with surface irrigation method and nitrogen was equal to 50% of recommended dose.

Scheduling irrigation with mulch under different sugarcane planting methods

A field experiment was initiated during second week of February 2016, to enhance crop and water productivity in sugarcane at research farm of the institute. The experiment comprising twelve treatment combinations was laid out in split plot design with four replications. Planting methods with or without mulch were the main plot treatments viz., 1. Conventional flat planting (75 cm row spacing) with mulch, 2. Conventional flat planting without mulch, 3. Paired-row trench planting (30:120 cm row spacing) with mulch and 4. Paired -row trench planting without mulch and irrigation scheduling as sub-plot treatments viz., irrigation scheduling at IW/CPE ratio of 0.60, 0.80 and 1.0. The sugarcane variety was CoPK 05191. Two irrigations were applied at the time of planting and 35 days after planting (time of germination) and subsequent irrigations were scheduled on the basis of IW/ CPE ratio in the respective plots.

Cane yield varied significantly due to different planting methods. Paired-row trench planting with trash mulching (120.97 t/ha) being at par with conventional flat method of planting along with trash mulching (115.19 t/ha) resulted in significantly higher cane yield than that of conventional flat method of planting (109.86 t/ha). The higher cane yield under paired row trench planting with mulching was attributed to more number of millable cane (1.38 and 1.34 lakh/ha) than the paired-row trench planting and conventional flat method of planting without trash mulching. The trash application led to higher sugarcane yields irrespective of irrigation scheduling. The irrigation schedules though did not influence the cane yield significantly but the irrigation at IW: CPE 0.8 recorded 2.3 and 3.9 per cent higher cane yield compared to 0.6 and 1.0 IW: CPE ratio, respectively.

The water use efficiency (WUE) is the function of yield and depends on the water used by a crop during the growing period. The WUE was found maximum under paired-row trench planting with trash mulching (0.80 t/ha cm) followed by conventional flat method of planting with trash mulching (0.76 t/ha cm) and paired-row trench planting (0.75 t/ha cm). The cane yield and water use efficiency can be increased significantly by trash mulching.

Agronomic performance of elite sugarcane genotypes

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

A field experiment was initiated to evaluate the agronomic performance of different elite genotypes of sugarcane (early) at higher fertility level (25% higher over recommended doses of NPK/ha) and at wider spacing (120 cm row to row). Total four genotypes viz., CoLk 11201, CoLk 11202, CoLk 11203, CoH 11262 along with two checks, Co 0238 and CoJ 64 were planted on 27th February, 2016 at 120 cm spacing and at 25% higher

recommended doses of NPK/ha. Germination% recorded at 45 DAP revealed that the genotype CoLk 11203 was at par with genotype CoJ 64 was superior to rest of the genotypes. The result also showed that the highest tillers at 120 DAP, shoot count at 240 DAP and NMC was registered with genotype CoLk 11203 and the lowest with CoH 11262. However, the highest stalk length (2.40 m), single cane weight (1.34 kg) and cane yield (76.81 t/ha) was recorded with Co 0238- a check variety for the trial. The highest cane yield in Co 0238 was mainly attributed to its higher single cane weight and cane length, which was significantly superior to all the remaining five genotypes. Among CoLk series of genotypes (early), CoLk 11203 was superior to CoLk 11201 and CoLk 11202 in respect to all the parameters. The performance of genotype CoH 11262 was significantly inferior to rest of the genotypes and gave the lowest cane yield (18.84 t/ha). The highest brix%, sucrose and purity % measured at 8 and 10-month stage was recorded with CoLk 11203, which was at par with Co0238. While genotype CoLk 11201 showed the lowest value of all these parameters at the same growth stage.

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

A field experiment was initiated to evaluate the performance of different elite genotypes of sugarcane (mid late) at higher fertility level and at wider spacing. Total eight genotypes viz., CoH 11263, CoPb 11214, CoPant 97222, CoLk 11204, CoS 8436, CoLk 11206, Co 11027, CoS 767 were planted in February 2016 at 120 cm spacing and at 25% higher recommended doses of NPK/ha. Germination% at 45 DAP revealed that the genotype CoLk 11206 was at par with CoPb 11214, CoS 8436 and Co S 767 but was significantly superior to Co 11027, CoH 11263, CoPant 97222 and CoLk 11204. The result showed that NMC was higher in CoLk 11204 and the lowest in CoH 11263. Cane yield was the highest (80.76 t/ha) in CoLk 11206 but was at par with CoPb 11214. Cane height was significantly higher in CoLk 11206 over rest of the seven genotypes tested. The highest cane yield in CoLk 11206 was mainly attributed to its higher single cane weight. Genotype Co11027 gave the highest brix%, sucrose and purity % measured at 12-month stage. While genotype CoS 767 showed the lowest value of all these parameters (brix, sucrose and purity) at the same growth stage.

Sustaining sugarcane yield under multiple ratooning through drip irrigation

The experiment was initiated after harvesting of 3rd ratoon crop of CoSe 92423 in first week of February, 2016. 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_2O was applied through fertigation in 20 equal doses. Irrigation water was kept equal to pan evaporation. Depth of irrigation water was kept at 80 mm in all the surface irrigation treatments and irrigations were scheduled at IW/CPE ratio equal to 1. The highest sugarcane yield (85.91 t/ha) was recorded in ring-pit planting system (Table 2.6) followed

Table 2.6. Sugarcane yield, irrigation water applied and irrigation water use efficiency

Treatment		Yield (t/ha)	IW (mm)	IWU efficiency (kg/ha-cm)
T1:	Planting at 75 cm row to row distance with surface irrigation and recommended fertilizers application in soil	45.07	880.0	512.12
T2:	Planting at 75 cm row to row and at alternate row drip irrigation-fertigation	73.00	536.4	1360.92
T3:	Paired row planting under 40×110×40 cm with drip irrigation-fertigation	64.49	536.4	1202.25
T4:	Paired row planting under 45×135×45 cm with drip irrigation-fertigation	64.98	536.4	1211.44
T5:	Paired row planting under 60×120×60 cm with drip irrigation-fertigation	78.94	536.4	1471.75
T6:	Paired row planting under 40×110×40 cm with sub-surface drip irrigation-fertigation	70.71	536.4	1318.25
T7:	Surface drip in ring-pit planting method (105×75 cm) with drip irrigation-fertigation	85.91	536.4	1601.62
T8:	Planting at 90 cm row to row distance with surface irrigation and recommended fertilizers application in soil	44.24	880.0	502.74
	SE±	2.72		46.20
	CD (P=0.05)	4.80		81.35

by 60-120-60 paired row planted surface drip irrigated crop (78.94 t/ha). The lowest sugarcane yield (44.24 t/ha) was recorded in surface irrigated crop planted at 90 cm spacing. The highest irrigation water use efficiency (1601.62 kg/ha-cm) was recorded in ring-pit planting system followed by 60-120-60 paired row planted surface drip irrigated crop (1471.75 kg/ha-cm). The lowest efficiency (502.74 kg/ha-cm) was observed in surface irrigated crop planted at 90 cm spacing.

ICAR funded Agri-consortia research programme on water

The experiment was conducted with eight early and eight late maturing sugarcane varieties. Amount of irrigation water applied was cent per cent crop water requirement (M1) and 75 per cent crop water requirement (M2) at 40 per cent depletion of available soil moisture (S1) and 75 per cent depletion of available soil moisture (S2). Sugarcane varieties responded significantly to different irrigation treatments (Fig. 2.1 and 2.2).

In early maturing varieties group, for M1S1 treatment, the highest number of millable canes (NMC) was observed in CoLk 09202 followed by Co 0238 and the lowest number was in CoJ 64 (Fig. 2.1). For M2S1 treatment, the highest number of NMC was observed in CoLk 09202 followed by CoLk 94184 and the lowest number was in CoSe 03234. For M2S2 treatment, maximum NMC was observed in CoPK 05191 followed by CoLk 94184 and the lowest was in CoJ 64. For M1S2 treatment, the highest NMC was observed in CoLk 09202 followed by CoPK 05191 and the lowest was in Co 0238. Regarding yield, in M1S1 treatment, the highest sugarcane yield was observed in CoPK 05191 (121.17 t/ha) followed by Co 0238 (107.85 t/ha) and the lowest was in CoS 8436 (53.44 t/ha). For M2S1 treatment, the highest yield was observed in CoPK 05191 (116.46 t/ha) followed by Co 0238 (115.09 t/ha) and the lowest was in CoLk 09709 (55.74 t/ha). For M2S2 treatment, the highest yield was observed in CoPK 05191 (116.41 t/ha) followed by CoLk 94184 (68.24 t/ha) and the lowest was in CoJ 64 (44.30 t/ha). For M1S2 treatment, the highest sugarcane yield was observed in CoPK 05191 (111.63 t/ha) followed by Co 0238 (95.59 t/ha) and the lowest was in CoJ 64 (52.81 t/ha).

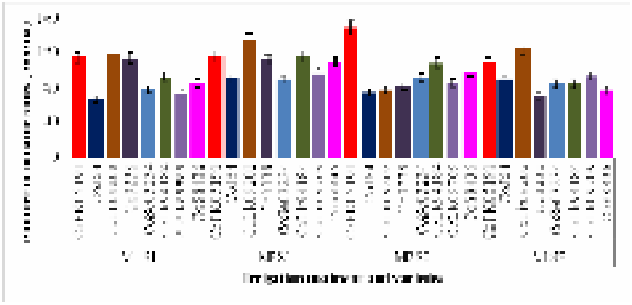


Fig 2.1. Number of millable canes of early varieties as affected by irrigation treatments

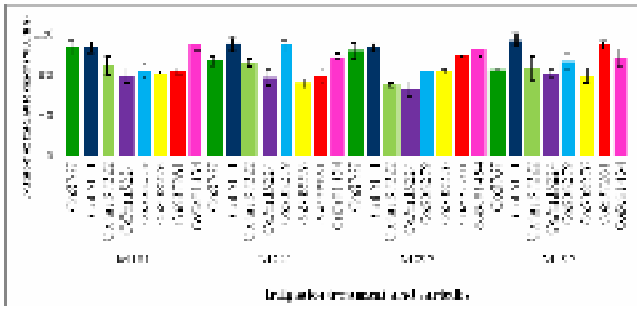


Fig 2.2. Number of millable canes of mid late varieties as affected by irrigation treatments

In mid-late maturing varieties group, for M1S1 treatment, the highest NMC was observed in CoSe 01434 followed by CoS 767 and the lowest was in CoPant 05224 (Fig. 2.2). For M2S1 treatment, the highest NMC was observed in Co 05011 followed by CoS 767 and the lowest was in CoS 08276. For M2S2 treatment, the highest NMC was observed in Co 05011 followed by CoSe 01434 and the lowest was in CoPant 5224. For M1S2 treatment, the highest NMC was observed in Co 05011 followed by CoS 97261 and the lowest was in CoS 08276. Regarding yield in M1S1 treatment, the highest cane yield was observed in CoSe 01434 (74.61 t/ha) followed by CoS 767 (67.81 t/ha) and the lowest was in CoS 97261 (51.70 t/ha). For M2S1 treatment, the highest cane yield was observed in CoSe 01434 (78.62 t/ha) followed by CoSe 01434 (69.81 t/ha) and the lowest was in CoS 08276 (58.98 t/ha). For M2S2 treatment, the highest cane yield was observed in CoSe 01434 (78.55 t/ha) followed by CoS 08279 (75.78 t/ha) and the lowest was in CoPant 5224 (44.80 t/ha). For M1S2 treatment, the highest cane yield was observed in CoS 08279 (75.14 t/ha) followed by CoPant 97222 (74.66 t/ha) and the lowest was in CoS 767 (49.17 t/ha).

The irrigation water use efficiency (IWUE) was significantly different from variety to variety within the same variety group. In early maturing varieties, CoPK 05191 resulted in the highest IWUE (1522 kg/ha-cm) followed by CoLk 09202 (1206.0 kg/ha-cm) and CoLk 94184 (943.6 kg/ha-cm). In mid-late maturing variety group, CoSe 01434 resulted in the highest (966.1 kg/ha-cm) IWUE followed by CoS 08279 (906.8 kg/ha-cm) and CoPant 97222 (862.8 kg/ha-cm).

CHAPTER 3

Management of Insect Pests and Diseases

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

Survey and surveillance remained a major activity of the Division during 2016-17 where in different sugarcane growing areas of Uttar Pradesh (command areas of DSCL; Balrampur Chini Mill; Dalmia Chini Mill; Bajaj Hindustan Sugar Mill; Oudh Sugar Mill and Seksaria Biswan Chini Mill). Incidence of red rot was noticed in CoS 8436, CoSe 92423, CoLk 8102, CoS 91269 and CoSe 95422. Localized incidence of red rot was noticed in Co 0238. In general, incidence of red rot was low (3-8%) but in some fields of CoLk 8102, CoSe 95422 and CoS 8436, it was about 25 per cent. Incidence of smut was observed in CoSe 92423 and Co 0238. GSD was noticed in most of the fields surveyed (1-3%). In CoS 91269 at some locations, incidence of GSD was higher (10-20%). The incidence of the minor diseases like Pokkah boeng is increasing substantially and it is mostly affecting the early varieties Co 0238, Co 89003, CoSe 95422 and CoS 8436. In some fields, Pokkah boeng incidence was noticed more than 30 per cent. Incidence of sugarcane mosaic was observed in varieties Co 0118 and Co 05011 while yellow leaf disease incidence was observed in Co 05011.

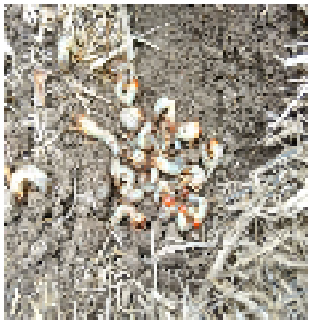
Sugarcane fields in command areas of New Swadeshi Sugar Mills, Narkatiaganj, Harinagar Sugar Mills Limited, Harinagar and Hasanpur Sugar Mills, Hasanpur, Bihar were surveyed. About 3-7 per cent incidence of red rot was recorded in CoSe 95422 and BO 130, Pokkah boeng was observed in the variety Co 0238 (5-20 %) and Yellow Leaf Disease (YLD) was noticed in CoLk 94184, Co 0118, BO 130 and Co 0238.

The insect survey was conducted in command areas of USDM, Ltd. Shamli; DSCL Sugar-Hariawan & Loni and the Simbhaoli Sugar Ltd., Chilwaria in U.P. 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 locations of USDM, Shamli. White grub (8-10%) was observed in varieties Co 89003, Co 05011 and CoSe 95422 in DSCL-Hariawan and Loni. The incidence of root borer is increasing and incidence was around 5% in Chilwaria areas with one location a heavy patch of root borer incidence (20%) was observed. Red mite incidence was recorded in varieties Co 89003, Co 05011 and CoSe 95422. Incidence of mealy bug and *Pyrilla* was in traces.

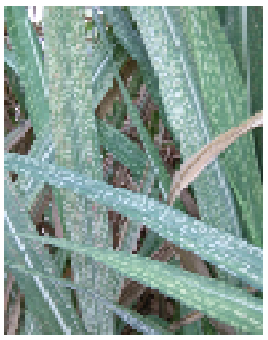
In Bihar, low to moderate incidence of *Pyrilla perpusilla* was noticed in CoLk 94184, CoP 112, Co 0238, Co 0118, BO 154, CoP 9301, Co 0232 and Co 0233.

In command areas of Dr. Vikhe Patil *Shakkar Karkhana*, Pravaranagar (Maharashtra), incidence of white grub was >80 per cent in Ashwin village and root borer (1-4%) was observed in CoM 0265.

White grub infested sugarcane crop

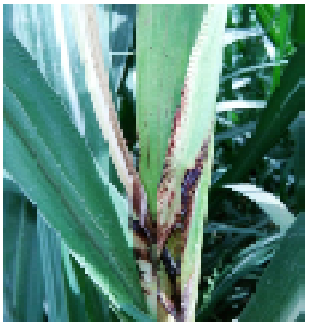



Grubs of white grub




Web mite infested leaves


Root borer infested cane | Larva of root borer

Pokkah boeng affected cane top

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

At ICAR-IISR farm, Yellow leaf disease (YLD) was recorded in 26 sugarcane genotypes and on cane basis incidence ranged from 1.25% to 29.95%, however, incidence was higher (44.45%) in CoS 91230 (Fig. 3.1, 3.2 and 3.3). To detect SCYLV, diseased samples from all 26 genotypes were subjected to DAC-ELISA test and none of them reacted positively (except the positive control: 1.52 absorbance at 405 nm) with the SCYLV antiserum in DAC-ELISA. The value of absorbance was ranged from 0.002-0.027 (Healthy Control: 0.083). The

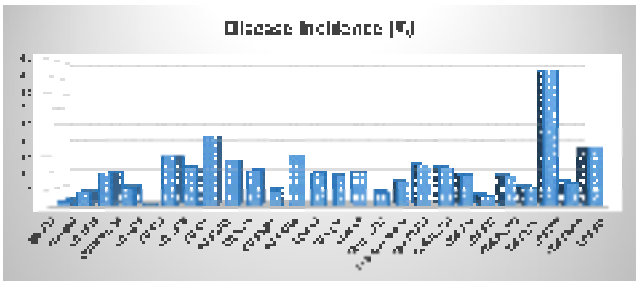


Fig. 3.1. Distribution of yellow leaf disease incidence (%) recorded on different sugarcane genotypes at IISR experimental farm

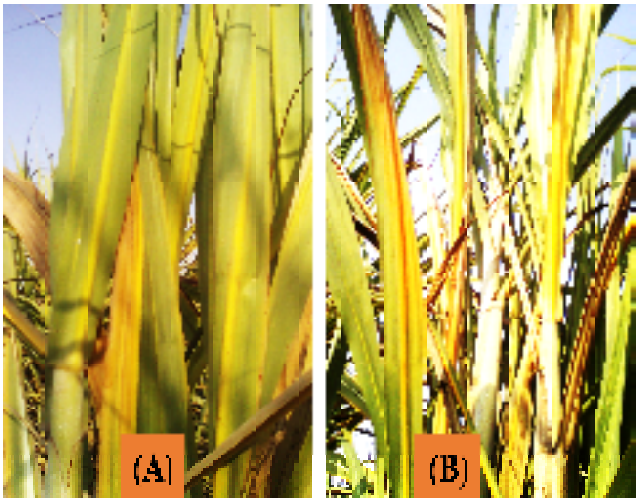


Fig. 3.2. **Yellow leaf disease (YLD) (A): severe yellow mid-ribs and (B): leaf necrosis and die-back of the plants**

Fig.3.3. Field view of the yellow leaf disease (YLD) affected sugarcane genotypes. showing yellowish mid-rib, severe yellow mid-ribs and leaf necrosis and complete necrosis of the plants

association of phytoplasma was detected by nested PCR that showed the amplification of ~1.8 kb and ~1.2 kb in first round and second round PCR on 1.5% agarose gel electrophoresis, respectively (Fig. 3.4). Despite several attempts of ELISA to detect SCYLV, positive result was not obtained. Efforts were made on the molecular detection of the SCYLV using the specific primers by RT-PCR assay. The YLD affected samples were collected from another set of 19 genotypes. PCR amplification of approximately 750 bp amplicons was obtained from four genotypes viz., Co 1148, CoS 510, CoS 91230 and CoS 90269 indicating the presence of SCYLV (Fig. 3.5).

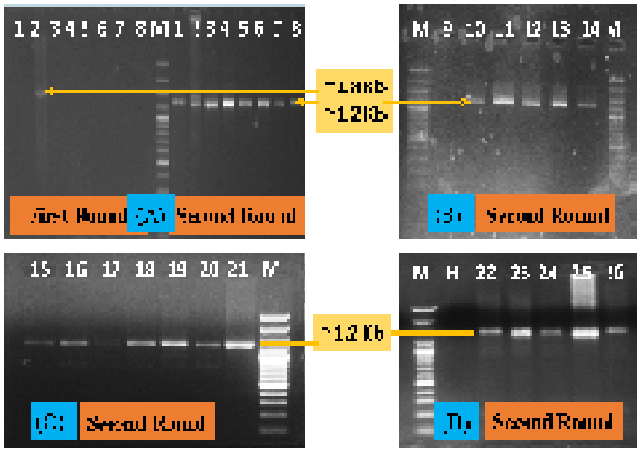


Fig. 3.4. PCR amplification of sugarcane yellows phytoplasma by nested PCR as: (A) first and second round PCR amplification of ~1.8 kb and 1.2 kb, respectively from (Lanes: 1: Bo 120, 2: Co 0238, 3: Co 1148, 4: CoLk 94184, 5: Co 0233, 6: Co 419, 7: Co 1336, 8: Co 453); (B) from lanes: 9: Co 05011, 10: Co 6425, 11: Co 89003, 12: Co 98014, 13: CoH 92, 14: CoH 119; (C) from Lanes: 15: CoH 99, 16: CoLk 8102, 17: CoPant 96219, 18: CoS 032258, 19: CoS 02264, 20: CoS 245, 21: CoS 687; (D) from lanes: 22: CoS 90269, 23: CoS 91230, 24: CoS 797, 25: CoS 90265, and 26: CoS 510

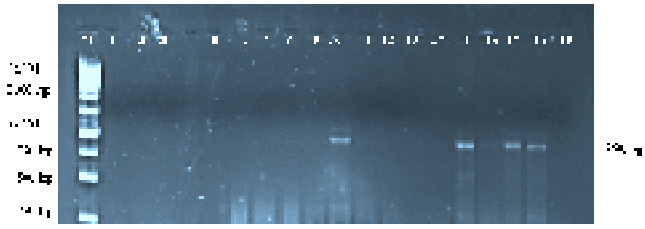


Fig. 3.5. RT-PCR amplification of *Sugarcane yellow leaf virus* (SCYLV) in yellow leaf disease (YLD) affected sugarcane genotypes. Lanes: M: 100 bp plus DNA ladder, 1: BO 91, 2: BO 99, 3: BO 109, 4: BO 110, 5: BO 120, 6: BO 128, 7: BO 129, 8: BO 130, 9: BO 136, 10: Co 1148, 11: BO 137, 12: BO 138, 13: BO, 139, 14: BO 141, 15: CoS 510, 16: CoS 687, 17: CoS 91230, 18: CoS 90269, and 19: BO 145

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

Whole cane of CoLk 94184 was subjected to serial heat treatment and planted with the two controls. Samples were collected for the detection of pathogen in early stage of growth. Visual observations on expression of YLD symptoms in relation to time period were recorded.

No YLD symptoms was noticed in any of the treatments and untreated control up to the 150 days after planting (DAP). YLD symptoms were noticed at 200 DAP in five plants of T_4 and 12 plants in C_2. At 250 DAP, symptoms were observed in T_2, T_4, C_1 and C_2. Infection of YLD was confirmed with molecular detection in 13, 10, 6 and 24 canes in T_2, T_4, C_1 and C_2, respectively. At the age of 300 DAP, T_2, T_3, T_4, C_1 and C_2 recorded YLD infection in 18, 10, 18, 13 and 36 plants, respectively. Rest of the treatments were free from YLD infection. At 350 DAP, all the treated canes were found infected with the YLD except in T_1 and T_5. Out of all the five treatments, T_1 (Serial thermotherapy for two hours through MHAT at 50°C for three consecutive days) and T_2 (Standard MHAT) were found effective.

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

During 2016-17 crop season, 39 sugarcane germplasm/genotypes viz., A-1-2, B-4-2, B-3-9, C-1-11, C-3-6, LG 11158, LG 11411, LG 11414, LG 11420, LG 11428, LG 11429, LG 11440, LG 11479, LG 11484, LG 11485, LG 11501, LG 11511, LG 11512, LG 11515, LG 11524, LG 11526, LG 11533, LG 11564, LG 11569, LG 12022, LG 12027, LG 12028, LG 12032, LG 12033, LG 12035, LG 12038, LG 12061, LG 12090, LG 12403, LG 12412, LG 12443, LG 12448, LG 12461 and LG 12470 were evaluated against two pathotypes of red rot (Cf 08 and Cf 09) using standard plug method and smut (sett – dip inoculation) and wilt (natural incidence).

Red Rot

Out of 39 genotypes, 18 genotypes viz., B-4-2, C-3-6, LG 11411, LG 12027, LG 12090, LG 11414, LG 11420, LG 11440, LG 11484, LG 11485, LG 11526, LG 11533, LG 11564, LG 11511, LG 12028, LG 11512, LG 12022 and LG 12032 were resistant (R) to moderately resistant (MR) against both the pathotypes (Cf 08 and Cf 09).

Eight genotypes namely LG 12027, LG 11479, LG 12035 LG 11158, LG 11429, LG 11512, LG 12033 and LG 12470 were resistant (R) to moderately resistant (MR) against Cf 08 and susceptible (S) to Cf 09.

Seven genotypes viz., LG 11428, LG 11569, LG 12038, LG 12061, LG 12412, LG 12443 and LG 12448 were rated highly susceptible (HS) and two genotypes viz., LG 11501 and LG 12430 were rated MS to both the pathotypes (Cf 08 and Cf 09).

Four genotypes showed intermediate behaviour. LG 11524 was MR against Cf 08 but MS to Cf 09, whereas

B-3-9 and LG 12461 were S to MS against Cf 08 but MR to Cf 09. Genotype A-1-2 was susceptible (S) to Cf 08 and resistant (R) to Cf 09.

Smut

For evaluation against smut, sett-dip inoculation was carried out at planting. Out of 39 genotypes evaluated, nine genotypes viz., LG 11414, LG 11515, LG 11569, LG 12032, LG 12038, LG 12403, LG 12443, LG 12448 and LG 12470 were susceptible (S) and the remaining 30 genotypes were tolerant to smut.

Wilt

Natural incidence of wilt was observed in seven genotypes viz., B-3-9, LG 11428, LG 11515, LG 11533, LG 12027, LG 12090 and LG 12443.

Enhancing efficacy of *Trichoderma* basedred rot management system

Molecular characterization of 38 *Trichoderma* isolates was carried out by multiplex PCR assay using four species specific primers (for *T. harzianum, T. virens, T. longibrachiatum* and *T. asperellum*). Twenty isolates showed the amplification of approximately 825bp amplicon that is corresponding to *T. harzianum* while eight isolates showed amplification of a 450bp amplicon and it is corresponding to *T. longibrachiatum*. It indicates that sugarcane soil harbours predominantly *T. harzianum* isolates. Forty eight *Trichoderma* isolates were screened for ammonia production and seven isolates viz., STr-3, STr-29, STr-30, STr-90, STr-93, STr-96 & STr-108 were identified as potential ones. Field studies were carried out to evaluate the potential of two promising *Trichoderma* isolates (STr-83 & STr-108) for red rot management. Three-bud setts of variety Co 1148, inoculated with *C. falcatum* (Cf 01) by sett-dip method (10^4 spores/ml) before planting. Talc based formulations were prepared and applied as sett treatment; soil application was carried out through *Trichoderma* multiplied culture (TMC) on FYM @ 220 kg/ha in furrows at planting. Soil treatment through TMC as well as combination of sett treatment + soil treatment were more effective against red rot (43% to 56.3% reduction) as compared to sett treatment alone (35% reduction). *Trichoderma* application as sett treatment + soil treatment also resulted in significantly higher cane yield relative to inoculated control (63.3 and 68.5 t/ha in STr-108 and STr-83 treatment, respectively).

Mass multiplication of *Trichoderma* on cheaper substrates and development of suitable delivery system for disease management in sugarcane

A field experiment was conducted with CoLk 94184 to find out the suitable method for the application of *Trichoderma* in sugarcane. Three treatments including untreated control without *Trichoderma*, furrow application of *Trichoderma* multiplied culture (TMC) on farmyard manure @ 220 kg/ha at planting and sett dipping in aqueous suspension of *Trichoderma* (10^6/ml) for 30 min before planting were adopted. There was no significant difference in yield and quality parameters.

Mechanism of resistance against top borer of sugarcane

The experiment was conducted with nine sugarcane varieties viz., CoLk 94184, Co 0238, CoJ 64, CoPant 97222, CoS 94257, CoS 96268, CoS 767, CoSe 92423 and CoLk 8102 in RBD with three replications. Incidence of III brood of top borer was low in all the varieties (0.00 to 7.22%). In IV brood, incidence of top borer was maximum in Co 0238 (10.34%) followed by CoSe 92423 (8.13%) and rest of the varieties received less incidence. Morphological parameters such as cane length, cane girth, leaf length, leaf width and width of mid-rib were recorded but no correlation with these parameters could be established.

Development of technique of mass multiplication of larval parasitoid for management of sugarcane top borer

Field collected top borer larvae and laboratory reared *Corcyra* larvae were used as host for rearing of *Isotima javensis* and *Stenobracon nicevillei*. Semi natural conditions were created by putting the larvae in groove made in cane stalk and a hole was also made to facilitate the parasitic activities. *Isotima javensis* accepted top borer larvae only, while *Stenobracon nicevillei* accepted both of the larvae for parasitisation but it required two larvae of *Corcyra cephalonica* to complete its life cycle.

Containment of major insect-pests of sugarcane through habitat modifications

To contain the insect-pests through habitat modifications, trap crops grown in the sugarcane agro-ecosystem *i.e.*, coriander, mustard, marigold, tomato, brinjal, sorghum and maize were taken to study the push-pull effect.

The incidence of top borer (I brood) was low (2.31-4.06%); II brood was 21.67%, 23.04%, 25.85%, 27.27%, 29.81% and 41.36% in intercropped with marigold, mustard, coriander, brinjal, tomato and sole sugarcane, respectively. Incidence of III and IV brood ranged from 8.81-14.37% and 7.10-13.57%, respectively with various trap crops as against sole sugarcane (15.62 and 13.57%). The minimum incidence of III and IV brood was recorded in plots along with sorghum and maize. The incidence of top borer (V brood) was low (3-4%). The incidence of

internode borer was the lowest in sorghum and maize (26-29%) followed by other trap crops (30.87-37.02%) and sole sugarcane (40.07%).

The egg parasitisation of top borer (I Brood) was higher (30% parasitisation) in plot having marigold followed by coriander, tomato and mustard as against 7.3% in sole sugarcane.

The parasitisation of top borer larvae (III and IV brood) by *Rhaconotus scirpophagae, Isotima javensis* and *Stenobracon nicevillei* was observed as 16-26.33% and 25.66-39.66%, respectively with various trap crops as compared to sugarcane sole crop (10.41 and 22.33%). Larval parasitoid, *Cotesia flavipes* parasitized 20.56-29.66% larvae of internode borer.

Semio-chemicals for the management of sugarcane top borer

Experiment was conducted with CoLk 8102, Co 0238 and CoJ 64. n-Hexane based extract of field collected egg, larvae and pupae of top borer was applied as foliar spray on standing sugarcane crop coinciding the stage of the pest in the crop.

In top borer (III Brood), egg parasitisation in plots treated with egg extract was 66.67, 80.00 and 70.00 per cent as against 40.00, 50.00 and 40.00 per cent in untreated plots of CoLk 8102, CoJ 64 and Co 0238, respectively. The larval parasitisation by *Rhaconotus* in CoLk 8102 and CoJ 64 was higher (40.00 and 60.00%) over untreated control (20.00 and 40.00%), Parasitisation by *Stenobracon* spp. was higher (40.00%) in CoJ 64.

In top borer (IV Brood), egg parasitisation in plots treated with egg extract was 23.33, 30.00 and 16.67 per cent as against 23.33, 16.67 and 2.00 per cent in untreated plots of CoLk 8102, CoJ 64 and Co 0238, respectively. The larval parasitisation by *Rhaconotus* in CoLk 8102 and CoJ 64 was higher (60.00%) over untreated control (20.00 and 40.00%), Parasitisation by *Stenobracon* spp. was higher (40.00%) in CoLk 8102. Parasitisation by *Isotima javensis* was observed in CoLk 8102 (20.00%). There was significant difference in top borer incidence.

Biological control of sugarcane moth borers, Pyrilla & scale insects through exotic and indigenous parasitoids and predators

The incidence of early shoot borer (6-21%) was observed in Dadh (Bk.), Pathare, Loni (Bk.), Kasi Vishweshwar, Tisgaon, Kolhar (Kh.), Rajuri, Kolhar, Aswi bk., Tisgaon & Lohgaon villages in command areas of sugar mill from April to March. Pyrilla incidence (3-22 nymph & adults/leaf) and its parasitoids (1-7 cocoon of *Epiricania* /leaf) were recorded from July to November in Pravaranagar area. Incidence of scale insect, *Melanaspis glomerata* (10-12%) was recorded in variety CoM 265. Its parasitoid *Adelencyrtus mayurai*, *Adelencyrtus moderatus* and *Botroideclava bharatiya* were active in the area. White fly incidence was observed on poorly managed plant and ratoon crop (12 30%) in Dahod, Kolhar, Bableshwar, Loni and Mandave, Fatyabad villages. The incidence of woolly aphid ranged 5-10% in Co 86032 and it was naturally controlled by its bio-agents. Incidence of white grub was recorded in Pravaranagar, Ashwi, Kholar, Khokhar, Hanumantgaon, Nandur, Mamdhapur, Chinchpur, Dadh, Fatyabad and Pathare villages, incidence ranged from 15 to 25%. In some fields, the incidence was up to 90%. The egg parasitoid *Trichogramma chilonis* mass multiplied in the laboratory on *Corcyra cephalonica* and a total of 1,09,50,000 adults of *Trichogramma chilonis* (as Trichocards) were released in 547.50 acre of sugarcane crop of 188 farmers against early shoot borer from June 2016 to February 2017.

AICRP (S)

Identification of pathotypes in red rot pathogen

During 2016-17, 19 new isolates *i.e,* three isolates from CoS 8436 (IR - 121, IR - 122 and IR - 123); three isolates from CoSe 92423 (IR - 124, IR -125 and IR - 126); three isolates from unknown variety (IR - 127, IR - 128 and IR - 129); five isolates from Co 0238 (IR - 130, IR - 131, IR - 132, IR - 135 and IR - 136); two isolates from CoLk 8102 (IR - 133 and IR - 134) and three isolate from CoSe 95422 (IR - 137, IR - 138 and IR - 139) 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, Khakai (*S. sinense*), Baragua (*S. officinarum*) and SES-594 (*S. spontaneum*) by plug method of inoculation. Except Co 0238 isolates, the virulence pattern of other isolates more or less matched with the existing pathotypes of this zone. It was observed that Co 0238 isolates giving intermediate reaction to BO 91; susceptible reaction to Co 62399, CoS 767, Khakai, Co 419 and CoJ 64 and resistance to SES 594, Baragua, Co 997, Co 975 and CoC 671. Thus, indicating the existence of gained virulence for BO 91 and loss of virulence for Co 997 and CoC 671. However, further studies are required to confirm the finding.

Evaluation of zonal varieties against red rot, smut and wilt

North West Zone (ICAR-IISR, Lucknow)

During 2016-17, 42 genotypes were evaluated against red rot, smut and wilt and YLD under IVT (Early), AVT (Early)-I Plant, AVT (Early)-II Plant, IVT (Mid late), AVT (Mid late)-I Plant, AVT (Mid late)-II Plant groups.

In IVT (Mid late), CoPb 13182 was resistant (R) by plug and nodal method against both the pathotypes (Cf

08 and Cf 09). CoPb 13183 and CoS 13233 were highly susceptible (HS) against both the pathotypes (Cf 08 and Cf 09). In AVT (Mid late)-II Plant, CoH 11263 was resistant (R) by both the methods against Cf 08 and Cf 09. In AVT (Early)-II Plant, CoH 11262 was highly susceptible (HS) against both the pathotypes. The remaining genotypes were rated in-between.

Out of 42 genotypes tested for smut tolerance, twenty genotypes viz., Co 13034, CoLk 13203, CoS 13231, Co 12026, Co 12203, CoPant 12221, CoLk 11202, CoLk 11203, Co 13035, CoPb 13182, CoS 13232, CoPb 13183, Co 12029, CoH 12263, CoLk 12205, CoPb 12211, Co 11027, CoH 11263, CoLk 11204 and CoLk 11206 were susceptible.

Natural incidence of wilt was observed in five genotypes viz., CoPant 13222, CoS 13231, CoH 11262, Co 13036 and CoPant 12226. Yellow leaf disease (YLD) incidence was also observed in eight genotypes viz., CoLk 13201, CoPb 13181, Co 12027, CoH 13263, CoPb 13182, CoH 12263, CoS 12232 and CoPb 11214.

North Central Zone (ICAR-IISR RC, Motipur)

In North Central Zone, 23 genotypes were evaluated against red rot, smut, wilt and YLD. In IVT (Early), all the genotypes except CoP 13437 were moderately resistant (MR) against Cf 07 and Cf 08. In AVT (Early)-I Plant, all the genotypes except CoSe 12451 were moderately resistant (MR) against the pathotypes. In AVT (Early)-II Plant, all the genotypes were moderately resistant (MR) against both the pathotypes. In IVT (Mid late), two genotypes viz., CoP 13439 and CoSe 13454 were moderately resistant (MR) against both the pathotypes. In AVT (Mid late)-I Plant, all the genotypes except CoP 12438 were moderately resistant (MR) by plug and nodal methods against Cf 07 and Cf 08. In AVT (Mid late)-II Plant, again all the genotypes except CoSe 11455 were moderately resistant (MR) against both the pathotypes (Cf 07 and Cf 08).

Out of 23 genotypes tested, seven genotypes viz., CoP 13437, CoP 12436, CoSe 12451, CoP 11437, CoP 13438, CoP 12438 and CoSe 11454 were susceptible and remaning 16 genotypes were tolerant to smut. Natural incidence of wilt was observed in four genotypes viz., CoSe 13452, CoP 13438, CoSe 13453 and CoP 12438. Yellow leaf disease (YLD) incidence was also observed in six genotypes viz., CoP 13437, CoP 11436, CoP 11437, CoP 13439, CoSe 13454 and CoLk 09204.

Management of yellow leaf disease through meristem culture

The work was initiated during April 2016. Meristem tip culture, regeneration was practiced for YLD affected sugarcane genotypes induding CoLk 9709, Co 05011 and Co 0238. The samples were indexed one month after transplanting to the main field for SCYLV by ELISA and SCYLP by nested PCR. Results revealed negative reaction against both the pathogens.

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

In mid late maturing group, 11 sugarcane genotypes viz., Co 12029, Co 11027, CoH 12263, CoPb 12211, CoLk 12205, CoH 11263, CoLk 11204, CoLk 11206, CoPb 11214, CoS 12232, CoPant 12226 and two standards (CoS 767 and CoPant 97222) were evaluated for their reaction to major insect pests. CoH 12263, CoPant 12226, CoPb 12221, CoS 12232, Co 11027, CoLk 11206 genotypes showed MS reaction to stalk borer and CoS 767 showed HS reaction. CoH 11263 showed HS reaction to Internode borer and rest of the genotypes showed MS reaction.

In early maturing group, seven genotypes viz., Co 12027, CoH 12262, CoLk 11201, CoLk 12203, CoPant 12221, CoLk 11202, CoLk 11203, and one standard (Co 0238 and CoJ 64) were evaluated for their reaction to major insect pests. One genotype, CoH 11262 showed MS reaction to top borer (IV brood) and rest of the genotypes showed LS reaction. Genotype, CoH 11262 was HS to stalk borer, internode borer and rest of the genotypes were MS.

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

Experiment on monitoring of insect pests of sugarcane was carried out with CoLk 8102. Planting was done in February-March, 2016. Recommended agronomic practices were followed to raise a good crop. Periodic observations on incidence of insect pests and parasitoids of pests were recorded. Germination was 45.00%. Incidence of top borer III and IV brood was 1.11 to 16.67 and 6.09 to 12.00%, respectively. Incidence of root borer was 26.67 to 58.82% in July and in September, it was 50.00 to 88.89%. Incidence of internode borer was 14.11 to 40.00%. Incidence of stalk borer was low. The incidence of *Pyrilla perpusilla* was low. Adult and nymph parasitoid of *Pyrilla, Fulgoraesia* (*Epiricania*) *melanoleuca* was active. Incidence of mealy bug was cent per cent. Incidence of black bug was moderate to severe. White fly was in traces. Parasites like *Telenomus beneficiens*, *Stenobracon* sp., *Rhaconotus* sp., *Isotima javensis*, *Fulgoraesia* (*Epiricania*) *melanoleuca* were present 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

Work on rearing of egg parasitoid *Eumicrosoma* sp.the parasitoid of black bug *Dimorphopterus gibbus* (Fab.) was carried out. About 50 fresh eggs of a black bug were offered to five pairs of parasitoid, *Eumicrosoma* in glass vials on parasitization host eggs turned shiny black. Adult wasps emerged out in 8-10 days after parasitisation. In winter months, rearing of parasitoid is done in BOD at 27±1 ^{0}C. Parasitisation of eggs was > 60%. The parasitoid was successfully reared on the eggs of black bug, *D. gibbus* throughout the year in the laboratory.

Management of borer complex of sugarcane through lures

To evaluate the effect of sex pheromones on incidence of borer pests of sugarcane, a field experiment was conducted in one acre of sugarcane field with CoLk 8102. Planting was done in the month of February 2016.

Six sex pheromone traps were installed in 0.5 acre sugarcane field and rest half area was kept without traps for comparison. Sex pheromone lures for top borer were procured from PCI, Bangaluru (India). Water and mobile oil were changed daily after recording mot catches. Lure Septa for top borer were changed at 20 days intervals. In second and third brood, catches were observed while in fourth brood, low catches were observed.

Total moths of top borer caught from May to September, 2016 were 225. Incidence of top borer III, and IV brood in plot with sex pheromone traps was low.

Externally Funded Project

Studies on rhizospheric microbial diversity in relation to different sugar profile varieties for growth promotion and disease management

Nine sugarcane varieties namely CoJ 64, CoLk 94184, CoS 8436, Co 1148, CoLk 8102, CoSe 92423, SES 594, Baragua and Khakai were used for rhizospheric sampling of 50, 100, 150 and 250 days after transplanting. Serial dilution factor 10^{-5} has been followed to isolate the rhizosphere microbes. The bio-chemical studies of isolated microbes has been conducted. In catalase test of *Aspergillus* isolates, out of 22 tested six viz., A 03, 05, 15, 16, 18 and 19 were found excellent. Nine viz., A 02, 07, 08, 09, 10, 11, 12, 13 and 14 were found good, whereas remaining were non-performing. In *Trichoderma* isolates, out of 25 tested twelve viz., T09, 10, 12, 13, 14, 16, 17, 18, 20, 21, 24 and 25 were found good. In oxidase test, *Aspergillus* isolates A02, 07, 08, 09, 10, 11, 12, 13 and 14 were found good. In *Trichoderma* isolates, T09, 10, 12, 13, 14, 16, 17, 18, 20, 21, 24 and 25 were found good. In ammonia test, *Aspergillus* isolates A03, 05, 06, 07, 10, 11, 12, 13, 14, 15, 16, 17, 18 and 19 were found good. In *Trichoderma* isolates, T07, 08, 09, 11, 12, 13, 16, 17, 18, 20, 21, 22, 23 and 25 were found good. In HCN test, *Aspergillus* isolates A02, 03, 11, 12, 15, 16, 18 and 19 were best performing. In *Trichoderma* spp. Isolates, T07, 12, 13, 16, 17, 18, 19, 22, 23, 24 and 25 were found good.

CHAPTER 4

Research in Physiology and Biochemistry

Optimization of plant population for improving physiological efficiency of sugarcane

Application of *Ethrel* and GA_3 boosted yield of autumn planted crop (2015-16) to 274 t/ha against 330 t/ha in 2014-15. The difference in obtained yields are explained to be due to reduction in Tmax (6.8L/ha) due to early earthing up (April 2016) which suppressed formation of tillers at an early stage against Tmax of 11.6 L/ha in 2014-15 due to earthing up in June 2014, that rendered maximum tiller formation. *In situ* decomposition of trash along with GA_3 led to an increase in cane yield or about 16.9 t/ha against GA_3 alone in Ist ratoon crop initiated from spring plant crop. Impact of foliar applications of GA_3 at 90, 120 and 150 DAP was assessed at Motipur, Bihar. Increased Tmax to 5.64 L/ha, with tiller mortality of 46.5%, NMC of 3.02 L/ha and cane yield of 258 t/ha (average cane weight of 853 g) against Tmax of 3.02 L/ha, with tiller mortality of 44.7%, NMC of 1.67 L/ha and cane yield of 108 t/ha (average cane weight of 643 g) in control.

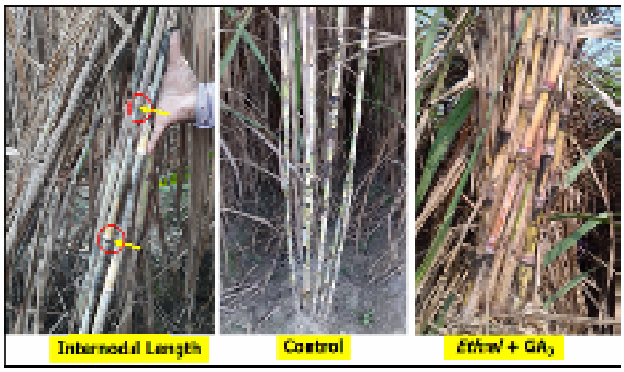
Modulating the expression of sucrose metabolizing enzymes for high sucrose accumulation in sugarcane

Foliar application of a mixture containing enzyme effectors and PGR ($MgCl_2$+$MnCl_2$ + ethrel @ 10 mM, 5 mM and 100/200/400 ppm ethrel) was performed at the start of ripening phase (in the month of October) using variety BO 91 (a mid late maturing variety) and CoJ64 (an early maturing variety) for improving sucrose content in cane stalk. Sucrose content in cane juice was determined in the month of November, December, January, February, March and April. Major results obtained indicated; (i) Sucrose content was enhanced in both the varieties by all the treatments; higher increase was obtained with chemical formulation containing 200 ppm Ethrel + Mg + Mn in different months of ripening (November till April). (ii) CoJ 64 showed higher level of improvement at all stage of analysis. (iii) Contrast to sucrose content, SAI activity decreased in treated cane stalk.

At IISR, Lucknow farm

Cane yield of 274 t/ha

At IISR Regional Centre, Motipur farm



Cane yield of 258 t/ha

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

The CWI enzyme, that plays key role in phloem unloading in sink tissues, exhibited higher expression in GA_3 samples (BO 91) at the elongation stage which decreased with maturity, whereas both SuSy and SPS, involved in regulation of sucrose accumulation, showed variable level of expression (Fig. 4.1). Real-time PCR

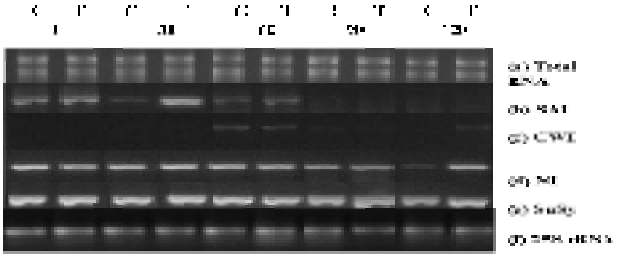


Fig. 4.1 Gene expression analysis based on qRT-PCR indicating differential expression in control (C) and GA_3 treated (T) top canes at 0, 30, 60, 90 and 120 days after spray

analysis with SAI primer has shown quantitative changes in transcripts level under normal and GA_3 perturbed conditions. The effect of GA_3 was clearly visible, 30 days after spraying (DAS), with a drastic increase in reducing sugar (RS) level, especially in the upper internodes, pointing to increase in sink potential. Even as the GA_3 effect waned 60 DAS, the GA_3 sprayed canes still showed prominently higher RS% values and complementarily, lesser sucrose%, brix%, pol% values, as compared to control canes. Visibly higher expression of SAI and modified expression of other genes in GA_3 treated plants, can perhaps be interpreted as a consequence of increase in sink strength caused by gibberellin treatment. This in turn, extrapolates to better assimilate uptake and hence, the obtained results affirm the role of GA_3 in facilitating better sucrose accumulation.

A transcriptomic level comparison and analysis was carried out on internodal samples of a high sugar accumulating variety CoLk 94184, to determine effect of exogenous application of GA_3. Overall, a total of 2,01,184 transcripts were identified, with median contig length of 450bp and an N50 length of 1029bp. Analysing the data from control and GA_3 treated canes, at 0.01 significance, a total of 1516 differentially expressing transcripts were identified in bottom internodes while their number was 1589 in top internodes. Total 80,287 transcripts were annotated using gene ontology (GO) (Fig. 4.2). A KEGG (enrichment) analysis grouped the transcripts into 153 plant-related functional categories. From among these, the transcripts which were functionally relevant to sugar metabolism and photosynthesis, were sieved out. These were then subjected to a homology match using Blastx analysis tool. A total of >50 transcripts were found to share homology with C_4 plants like sorghum and maize.

Minimizing post harvest sucrose deterioration and its molecular assessment in sugarcane

Using SAI gene, real-time PCR analysis was performed and results indicated a significant

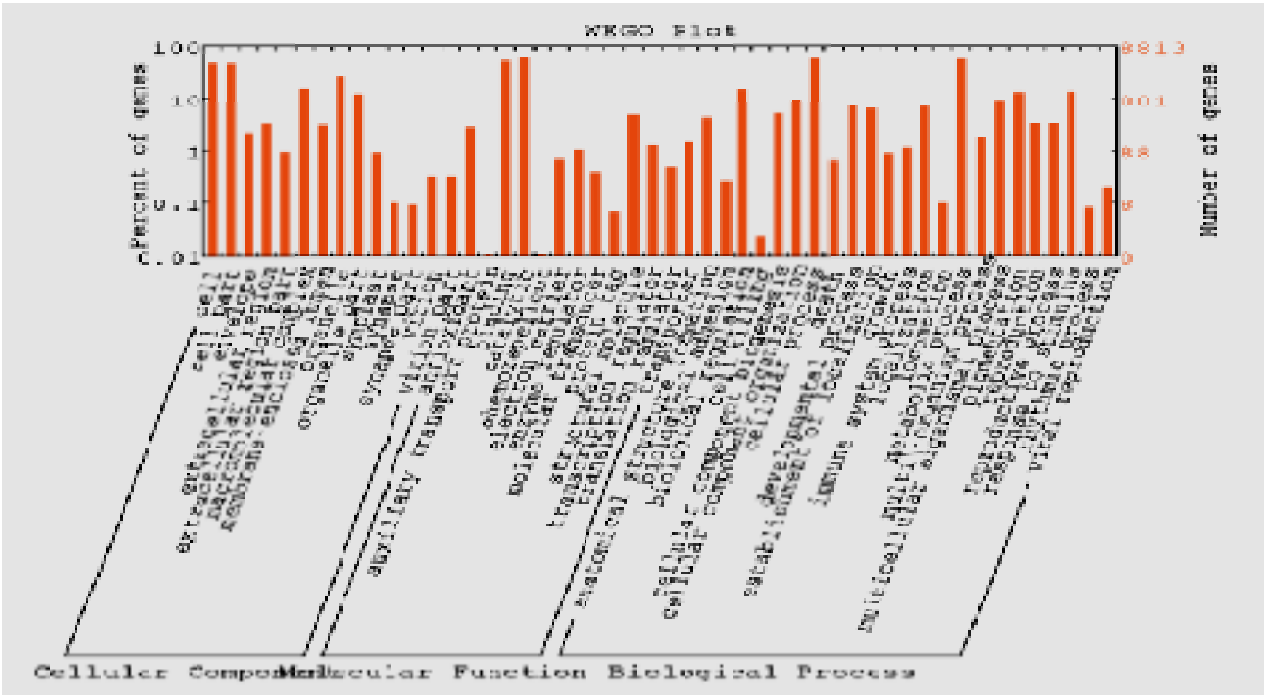


Fig. 4.2 Gene ontology classification of transcripts

quantitative change in the expression of SAI in control and BKC (Benzalkonium chloride) and BKC+SMS (Sodium metasilicate) treated canes. Total RNA was isolated at various stages of the treatments with chemical formulations and control samples. cDNA was first synthesized and after calibration, RT-PCR was conducted. 25SrRNA gene was used as a reference gene to conduct the PCR analysis. Reduction in expression of SAI gene was observed significant in BKC treated canes over control (untreated canes) indicating its role in checking cane quality deterioration (Fig. 4.3).

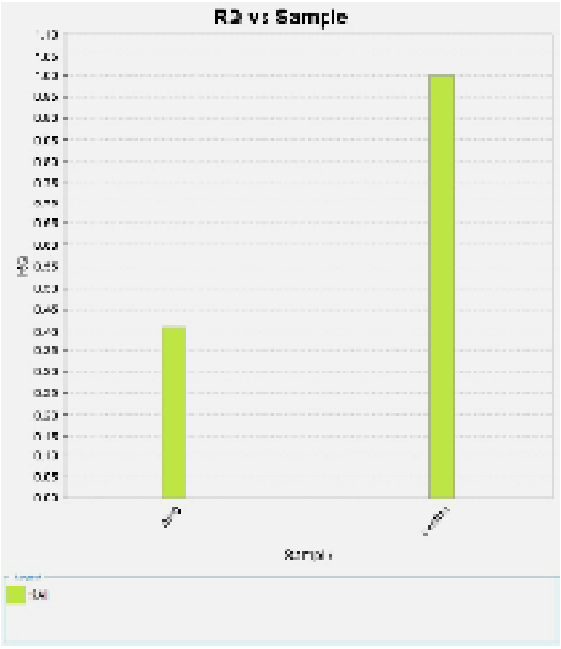


Fig. 4.3. Real-time PCR results indicating a significant reduction in SAI gene expression in BKC treated canes over control

Inter-Institutional Project

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

Waterlogged affected plants showed lower leaf, stalk, and whole clump dry weight, specific leaf weight, leaf area, SPAD, chlorophyll a, b, total chlorophyll, carotenoid contents and P and K contents in leaf tissues.

Under waterlogged condition, stalk elongation rate was varied widely among different genotypes and it ranged between 0.016-0.909 cm/day. SR/AR ratio was found the highest (5.59) in CoLk 07201 and the lowest (0.795) in S 5087/11. Tolerance indices for stalk dry weight showed significant positive correlation with tolerance indices for total dump dry weight, leaf weight, root weight, specific leaf weight, chlorophyll a, b, total chlorophyll, and carotenoids contents. Sugarcane genotypes had different tolerance indices for the studied parameters; D-6-13, S 5090/11 and S 5085/11 had greater tolerance indices for stalk and whole clump dry weight and S 5085/11, B-44-12 and CoS 767 for chlorophyll a, b total chlorophyll and carotenoid contents. Based on relative cane weight, S 5085/11, CoLk 12206, LG 06605, LG 04439, UP 9530 and D-6-13 were identified as the most waterlogging tolerant genotypes.

Significant difference was observed among genotypes for juice quality traits immediately after waterlogging (November) and at later stage of waterlogging (December and February). Juice quality attributes viz., degree Brix, sucrose % juice, juice purity, CCS % juice and S/R ratio were relatively higher in November and lower at later stage of waterlogging (December and February) as compared to control. Reducing sugar content was slightly higher in waterlogged affected plants in February. Sucrose % juice ranged from 16.19 (CoLk 12202) to 12.48 (LG 05020) in November, 16.54 (CoLk 12204) to 10.63 (A-46-11) in December and 17.33 (UP 9530) to 12.83 (BO 91) in February under waterlogged condition. With a general mean value, the highest increase (14.97% and 6.21% over control) was observed in D-6-13 and the maximum decrease in CCS% juice, juice purity (12.17%, 13.02% over control) was observed in CoJ 64 due to waterlogging. Based on juice quality attributes, CoLk 12202, CoLk 12204, D-6-13, UP 9530, CoLk 94184 may be grouped as tolerant genotypes.

ADH activity increased under waterlogging condition and it ranged from 0.021- 0.105 with mean average of 0.054 in control and 0.01-0.164 with mean average 0.061 in waterlogged; the maximum activity was observed in BO 91. APX and SOD activity was found the highest in genotype CoLk 04238 under waterlogged condition.

CHAPTER 5

Mechanization of Sugarcane Farming

Development of modified furrower type sugarcane cutter planter

Prototype of tractor operated deep furrow sugarcane cutter planter was evaluated at ICAR-IISR farm and also at farmers fields of Muzaffarnagar, Hardoi, Bahraich districts of Uttar Pradesh and Muzaffarpur district of Bihar. This multitasking equipment performs different operations involved in cane planting, such as sett cutting, deep furrow opening, placement of setts into furrows, application of fertilizers and insecticide in furrows and putting a soil cover over setts and compacting the soil cover with a tamping roller, simultaneously in a single pass. During field trials, each component of the machine functioned well. Farmers of Muzaffarnagar district reported yield increase of 10% by using the machine. It also reduced lodging of canes and improved ratoon crop due to deep roots of the plant crop. On an average, it took five hours for planting of one hectare with the help of four persons as against 40-45 man-days in manual planting. The cost of operation of sugarcane planting was saved by about 60%.

A battery operated spraying attachment was developed and integrated for spraying of herbicide simultaneously after soil covering. Four man-days were saved by using this attachments which was otherwise performed manually within 48 hours after sugarcane planting.

Prototype of tractor operated deep furrow sugarcane planter-cum-multi crop raised bed seeder (modified RBS cane planter) was designed, developed and field tested. It performs planting of two rows of sugarcane in deep furrows and sowing of two rows of companion crop on raised beds between two furrows, simultaneously in single pass of the machine. It was field tested at ICAR-IISR farm for planting of intercrops like wheat, blackgram (urdbean), greengram (mungbean), and mustard under FIRB method (Fig. 5.1, 5.2 and 5.3). The effective field capacity of the planter was 0.18-0.20 ha/h.

Design refinement of tractor operated sugarcane-cum-potato planter

Tractor operated sugarcane-cum-potato planter was designed and developed for mechanising simultaneous planting of two rows of sugarcane in deep furrows and two rows of potato on ridges as intercrop. Performance of the planter was tested in the field in sandy loam soil (Fig. 5.4). Effective field capacity of the planter

Fig. 5.1 Deep furrow sugarcane planter in field operation at farmer's field at Navala, Muzaffarnagar

Fig. 5.2 Deep furrow sugarcane planter with herbicide spraying attachment

Fig. 5.3 Deep furrow sugarcane planter-cum-multi crop raised bed seeder (modified RBS cane planter)

Fig. 5.4 Sugarcane-cum-potato planter infield operation

was 0.127 ha/h at forward speed of 0.5 m/s. The planter saved 511 man-h/ha (90%) labour and ₹ 10,440 per ha (76%) cost of planting as compared to conventional manual method. Irrigation water use efficiency, yield attributes and total yield increased significantly in potato-sugarcane intercropping as compared to relay cropping of potato and sugarcane. Benefit-Cost ratio was 2.57 in case of mechanized planting with the developed planter, 2.26 in manual intercrop planting and 1.84 in case of manual relay cropping of potato and sugarcane.

Development and evaluation of tractor operated multipurpose tool frame with attachments

Tractor operated multipurpose tool frame was designed and developed to attach different attachments for sugarcane cultivation. These attachments can be attached individually or in combination as per need.

Attachment for furrow opening

For selection of best furrow opener for opening the furrows for planting of sugarcane, a field experiment was conducted on a silt loam textured soil for already available three furrow openers viz., IISR furrower, IISR deep furrower and conventional type ridger operated at three average forward speed 0.26, 0.40 and 1.02 m s^{-1} and three average depths of 100, 150 and 250 mm. The parameters such as draft, specific draft, soil penetration resistance, ridge height, soil disturbed and germination percentage were determined. Soil penetration resistance decreased significantly with increasing operational speeds of each furrow openers and increased significantly with depth of furrows. Soil disturbed and draft force requirements increased significantly with the increase in operation speed and depth of furrow in all the furrow openers. Higher germination was observed after 30 and 45 DAP with IISR deep furrow opener at 250 mm depth. The lowest soil penetration resistance, minimum specific draft and better germination were found with IISR deep furrow opener. Hence, IISR deep furrower was used with multipurpose tool frame as an attachment for furrow opening (Fig. 5.5). A share made of carbon steel square rod of 25 mm × 650 mm was fitted at one end of the shank and the other end of the shank was attached with the frame with the help of angles, nuts and bolts.

Fig. 5.5 Multipurpose tool frame with furrow opening attachment

Attachment for fertilizer metering

A two stage fertilizer metering system was used. A free fall unit with adjustable height of the hopper within a range of 0-50 mm and vertical rotor with grooves metering mechanism were provided for metering of fertilizer. Two fertilizer boxes were provided in the machine. Each box was designed for 40-45 kg capacity to minimize the number of refills for the box. The fertilizer metering rotor was a PVC rotor with vertical grooves on periphery which offers free flow of fertilizer during metering. Diameter of rotor was 95 mm with seven grooves on its periphery. A ground wheel attached at the front side of the implement was provided to drive the metering rotors through chain and sprockets.

Attachments for intra-row herbicide spraying

For intra-row weeding in sugarcane crop, flat fan nozzle (PVC) was used for spraying selective herbicide on the crop along with inter-row weeding by the shovel and sweep. Four flat fan nozzles having spray angle 85^0 and discharge rate of 630 ml/min were used for spraying the herbicide to cover four rows of sugarcane planted at 75 or 90 cm row spacing. A pump having a flow rate of 3.1 litre/min was used which was connected through pipe with the main herbicide tank and then to the nozzle pipe. A 12 volt battery having back up of 6-8 hours was provided to operate the pump.

Attachment for inter-row interculturing

For interculturing in sugarcane crop with three row interculture equipment, six tines with shovel and three small full sweeps in between each pair of shovel tines were provided (Fig. 5.6). The total inter-row spacing covered during operations with mechanical tools will be 450 mm and intra-row width covered for herbicide application will be 300 mm.

Fig. 5.6 Prototype of multipurpose tool frame with interculture cum herbicide spraying and fertilizer application attachment

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

Two separate prototypes of tractor operated two row disc type ratoon management device with and without stubble saving attachments were designed and fabricated. Prototypes were tested in the field at IISR farm for performing ratoon initiation operations after harvesting of sugarcane (Fig. 5.7). Prototypes worked satisfactorily. Effective field capacity of the prototypes ranged from 0.25 to 0.35 ha/h.

Fig. 5.7. Two row disc RMD in operation

Development of cane node planter

Prototype of tractor operated cane node planter was designed and developed for mechanizing cane node method of planting. Preliminary field testing was conducted to evaluate the performance of the planter. Power operated cane node cutting machine was also developed.

AICRP on FIM

1. Under AICRP on FIM, 33 prototypes of equipments were fabricated and 34 prototypes were manufactured and supplied to stakeholders/ indentors

2. Tractor operated reaper binder was tested at IISR farm and farmers' field for harvesting of wheat crop in more than 3.0 ha area (Fig. 5.8). Machine performed harvesting and binding of wheat in a single operation. The effective working width of machine was 110 cm. The field capacity of the machine was 0.26 ha/h at 3.1 km/h forward speed. The height of cut was 7-12 cm. Only two persons (one tractor driver + one helper) were needed. A saving of 94% in labour and 20% in cost of operation was achieved (as compared to conventional practice).

Fig. 5.8 Operation of tractor operated reaper binder in the field for wheat harvesting

3. Prototype of Pant-ICAR sub-soiler cum differential rate fertilizer applicator was procured from M/s Punjab Engineers, Meerut. The preliminary testing of machine was carried out. The average depth of penetration of outer shovels and middle shovel was found as 15 cm and 21 cm. A field experiment was conducted to assess the performance of the machine in sugarcane planting with three treatments namely; T_1- Conventional planting at recommended dose of fertilizer, T_2-Sub-soiling and fertilizer application with the prototype + manual planting and T_3- Planting with deep furrow sugarcane cutter planter at recommended dose of fertilizer (Fig. 5.9). During testing in the field, machine was operated at forward speed of 1.8 km/h. The field capacity of the machine was 0.20 ha/h.

Fig. 5.9 Pant-ICAR sub-soiler cum differential rate fertilizer applicator in operation

CHAPTER 6

Diversification and Value-addition

Development of a jaggery furnace with efficiency boosting device

The diameter of holes on efficiency booster (EB) was increased to 4 mm in the unit and the unit was tested again following water boiling test. The results are summarized in Table 6.1.

The unit was further modified by providing nipples of 20 mm length and 4 mm diameter (Fig. 6.1) to direct flames and hot gases towards the pan bottom for more heat transfer.

Table 6.1. Comparison of EB with 1 mm and 4 mm holes

Parameter	With EB (1 mm holes)	With EB (4 mm holes)	Per cent increase/ decrease
Water evaporated	1.82 kg	1.94	6.59 (increase)
Evaporation/kg fuel	0.72 kg	0.77	6.94 (increase)
Fuel consumed/kg water evaporated	1.39 kg	1.30	6.47 (decrease)
Time requirement/kg water evaporation	0.41 hour	0.37 hour	7.31 (decrease)

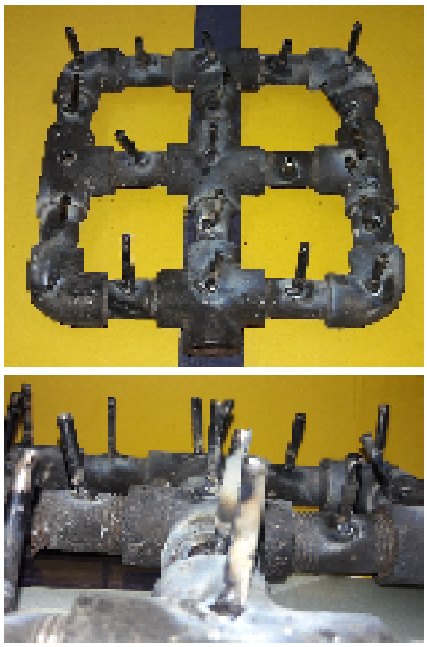


Fig. 6.1. Efficiency booster with 20 mm nipples of 4 mm diameter

Refinement of sugarcane cleaner-cum-washer unit

In the cleaning-cum-washing unit, two feed rollers and four scrubbing rollers have been provided. Wire brush on scrubbing rollers was replaced by wire mesh so that the cleaning could be achieved more efficiently.

Value addition of jaggery with Indian spices and herbs for increased market value

Experiments were repeated for value added jaggery making using identified Indian spices. Finalized quantity (Table 6.2) of all the selected spices were added to jaggery at a particular stage *i.e,*. in cooling pan while puddling when the temperature of concentrated sugarcane juice comes down to 55- 60°C. These spices were mixed thoroughly and the whole mass was transferred to the moulding frame for making 25 mm x 25 mm x 12.5 mm pieces. Processing of some spices prior to addition like grinding and roasting of turmeric, drying and grinding of ginger, grinding of black pepper and roasting of caraway and asafoetida was also done to exploit aroma in better way.

Table 6.2 Quantity of spices added to jaggery for value addition

Name	Quantity added (g/kg of jaggery)
Dried ginger powder	25
Turmeric powder	15
Caraway seeds	10
Black pepper powder	15
Asafoetida powder	1
Sesame seeds	400
Nigella seeds	15

Prepared value added jaggery samples were packed using butter paper and aluminium foil (Fig. 6.2).

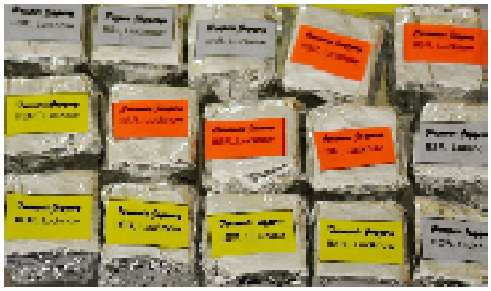


Fig. 6.2. Value added jaggery with Indian spices

Development of a semi-automatic jaggery manufacturing plant

A molten jaggery pumping unit was designed and developed. It consists of pump, water inlet valve, vacuum valve, vacuum breaker valve and suction valve (Fig. 6.3).

Fig. 6.3 Jaggery pumping unit under fabrication

Development of sugarcane juice extractor for household use

Pushers were developed for centrifugal (Fig. 6.4) juicer so that sugarcane stalk could be pushed on the grinding plate. Experiments were conducted to extract juice from cane directly. It was noted that rind of sugarcane was posing problems. Trials were conducted by removing the rind. With the peeled sugarcane stalk the juicer were able to extract 40% of sugarcane juice. The capacity of the juicer was one glass per minute.

Fig. 6.4. Centrifugal juicer

Development of jaggery gems using liquid nitrogen

The vessel for producing 0.5 kg of jaggery gems per minute has been designed (Fig. 6.5). It consists of molten jaggery gems tank, pump, multi point nozzle, high pressure jacketed tank for liquid nitrogen and a collector.

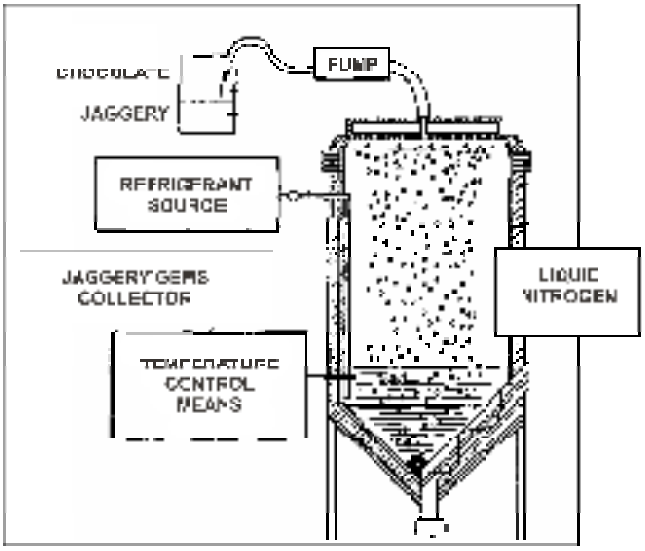


Fig. 6.5 Design of vessel for production of jaggery gems

Study on determining storage losses in food grains in FCI and CWC warehouses

FCI as well as CWC godowns at Raebareli, Basti and Dhamora were visited to collect data and samples as per guidelines issued. All the stacks in Basti were liquidated based on the reports of quality manager. Loss and gain percentage is given in Table 6.3.

Table 6.3. Loss or gain percentage in rice and wheat at different warehouses

Warehouse location	Commodity	Stacking month	Loss/gain, % after month				
			18	21	24	27	30
FSD, Dhamora	Wheat	June 2014	+0.10	+0.02	0.00	0.01	0.38
	Rice	June 2014	-1.14	-1.13	-1.36	-1.2	-0.87
CWC, Basti	Wheat	June 2014	+0.53	+0.33	+0.28	0.35	+0.65
	Rice	June 2014	-1.9	-1.7	-2.1	-2.02	-2.26
FSD, Raibareilly	Wheat	June 2014	+0.04	+0.04	-0.32	-0.41	-0.15
	Rice	June 2014	-2.69	-2.36	-2.64	-3.24	-2.85

CHAPTER 7

Sugarbeet Research

Developing sugarbeet varieties suitable for Indian agro-climates

Evaluation of fifteen test entries including two checks (LS 6 and IISR Comp 1) revealed that five test entries viz., SZ 35, LKC 2007, PAC 60008, LK7 and LKC HB maintained their superiority for sucrose content. SZ 35 was superior to the best check for leaf weight, Brix, and sucrose. Similarly, LKC 2000 was superior to the checks in most of the traits except leaf weight and purity (%).

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

The economics of sugarbeet cultivation on commercial scale in Punjab were further confirmed by carrying out a survey of 40 sugarbeet farmers in Amritsar and Batala districts. The cost of sugarbeet cultivation was ₹ 70,000/ha. The farmers harvested 85 tonnes /ha of sugarbeet and earned a gross return of ₹ 1,61,500 and net return of ₹ 91500 on account of this short duration crop in 2016-17.

The marketing system being followed for sugarbeet is the same as that for sugarcane, and the price offered for sugarbeet is less than the price of sugarcane. The price of the sugarbeet offered by the sugar mill during 2016-17 was ₹ 1900 per tonne. In comparison to sugarcane cultivation, sugarbeet occupies field for less duration, need just 2 hoeings and 3 irrigations. The labour requirement for weeding and interculturing is also less as compared to sugarcane cultivation. Moreover, its harvesting operations are also mechanized. The net returns per ha are high compared to resource use.

The sugarbeet farming in Punjab took shape due to contract farming between the mill and the growers. The contract is signed at the time of sowing by providing ₹ 50,000 as an advance to farmers towards seed, machine use, pesticides, and harvesting. The bond is executed to supply the produce to the mill and the amount given as advance by the mill is deducted.

CHAPTER 8

Economics, Statistics and ICT

Factors contributing economic viability of sugar and energy production complexes

To fulfil objectives of project, data were collected from 18 sugar mills from western, central and eastern U.P. during sugar season of 2015-16 and 2016-17. The selected sugar mills were classified as standalone or integrated complex owned by the cooperative or private sector. Besides the sugar mills, primary data were also collected from 240 sugarcane farmers to study the adoption of sugarcane production technology and examine the comparative economics of sugarcane in innovative sugarcane production technologies and traditional method. Simple tabular analysis used to estimate cost, return and net profit (Table 8.1).

Production constraints and way forward

Indian sugar industry provides livelihoods to nearly 7.5 million cane growers and 1.5 million skilled and semi-skilled workers employed in sugar mills. Sugarcane is faceing challenges as decline in cultivable land, water scarcity, fertilizer cost and escalation of labour wage and decline in profit. In spite of production constraints, sugarcane productivity in U.P. has increased from 59.3 to 67.7 tonne/ha and sugar recovery from 9.14 to 10.61% during 2011-12 to 2016-17. This was due to wide adoption of early maturing variety as area has increased from 9.26 to 52.8%. Major production constraints identified as late planting of sugarcane after wheat, cultivation of denotified cane varieties, low soil organic carbon, non-availability of quality seed of new varieties, indiscriminate use of pesticides, narrow row spacing, high seed cost, and imbalance plant nutrients application. To enhance cane production, minimize cost and maximize profit, farmers should adopt *Ghar Ghar Beej Yojana*, integrated nutrient and pest management, trench/FIRB planting method and water saving irrigation techniques.

Economics of sugarcane production

Comparative economics of sugarcane production in traditional and innovative sugarcane production techniques (ISPT) methods was worked out (Table 8.2). The cost of sugarcane production was ₹ 1,61,439 and ₹ 1,34,267 per ha in traditional and ISPT method, respectively. The high production cost in traditional method was mainly because of high seed cost as farmers use three bud setts and flood or check basin irrigation, without green manuring, high fertilizer and more labour wages for manual intercultural operations. However, in ISPT method, cost was less as they plant single bud setts, grow green manure crop, precision field leveling, FIRB/raised beds/trench planting at wider row spacing, saving irrigation water in trench/furrow, use RMD, trench openers for cane planting and intercultural operations. The results revealed a cost saving of 25-45%

Table 8.1. Comparative cost of sugarcane cultivation in traditional and ISPT methods

(in ₹/ha)

Particulars/cost components	Traditional	ISPT method	Cost saving (%)
Fixed cost components			
Depreciation	5207	5441	
Interest on fixed assets	4908	4612	
Rental value of owned land	28284	28663	
Total fixed cost	38399	38716	-0.83
Variable cost components			
Cane seed/setts	18543	10342	44.23
Fertilizer and manure	14572	11286	22.55
Plant protection chemicals	3567	3538	0.81
Human labour	37676	27234	27.72
Mechanical power	33261	34733	-4.43
Irrigation	15421	8418	45.41
Total variable cost	123040	95551	22.34
Total cost (Cost C)	161439	134267	16.83

Table 8.2 Comparative economics of sugarcane production in Uttar Pradesh

(in ₹ /ha)

Particulars/cost components	Traditional	ISPT method
Cost A_1	123040	95551
Cost B_1	151324	124214
Cost C_1	156232	128826
Total Cost (Cost C_2)	**161439**	**134267**
Yield (tonnes/ha)	71	85
Price (₹/tonne)	3120	3150
Cost of production (₹/tonne)	2274	1580
Gross return	221520	267750
Net return on Cost A_1	98480	172199
Net return on Cost C	60081	133483
Benefit-Cost (BC) Ratio	**1.372**	**1.994**

onseed, fertilizer, irrigation and labour in ISPT method.

Farmers realized higher crop productivity and reap better economic returns in ISPT as compared to traditional method with adoption of EMV's such as Co 0238, CoLk 94184, Co 0118 etc and intercropping with pulses, oilseeds and vegetables in autumn planted cane, trench planting, wider row spacing, single/two bud sett in place of three bud setts, irrigation in trench/furrow.

Farmers cultivate pulses (chickpea, lentil, cowpea, fieldpea etc.), oilseeds (rapeseed and mustard, linseed) and vegetables (potato, cabbage, cauliflower, onion, garlic) as intercrops in autumn planted cane under ISPT to use wider row space (4-6 feet) and earned a net income of ₹ 36,500 to ₹ 64,320/ ha on the basis of intercrop sown and prevailing market price received. Farmers also grow summer pulses as intercrops in spring planted cane to get additional income in IPST method and reap net income up to ₹ 27,500-31,000/ha. BC ratio of 1.994 revealed that cane cultivation was more profitable in ISPT as compare to traditional method (1.372).

Economics of sugar and co-products processing

The sugar processing cost includes expenses incurred by sugar mills on cane procurement and various conversion costs, mills over head expenses for processing cane into sugar and co-products (Table 8.3). An analysis revealed that sugar production cost in U.P. varied from ₹ 32,658 to ₹ 40,865 per tonne during year

Table 8.3. Cost of sugar production during crushing season 2016-17 in U.P.

(in ₹/tonne)

Particulars/Cost component	Standalone		Sugar + Co-gen	Sugar+ Distillery+ Co-gen
	< 5,000 TCD		5,000-10,000 TCD	>10,000 TCD
	Co op.	Private		
Sugarcane	32742	30395	28987	27454
Fuel and power	519	541	473	347
Chemicals	223	242	211	234
Manu. and processing	571	416	310	295
Repair and maintenance	609	375	294	194
Salary and wages	1726	1326	1183	956
Management and adm.	685	518	504	494
Packaging material	493	465	406	383
Interest	502	396	307	294
Depreciation	832	663	562	267
Excise duty and taxes	950	950	950	927
Commission charges	729	695	632	675
Misc. expenses	284	209	217	138
Total cost	40865	37191	35036	32658
Cane crushed (Lakh qtl.)	46.28	68.94	102.73	173.28
Sugar recovery (%)	9.58	10.43	10.94	11.48
Sugar production (lakh qtl.)	4.43	7.19	11.24	19.89
Crushing duration	152	149	146	158

2016-17 in a stand alone, integrated sugar-energy complex owned by cooperative or private sector. The cost of sugarcane used as raw material has a lion's share of 80-85% in aggregate sugar processing expenses. Sugarcane crushing capacity of sugar mills varied from 1,800 to 14,000 TCD. Dwarikesh Sugar Mill, Bundki has accomplished maximum sugar recovery of 12.35%, in 2016-17. In U.P., out of 116 sugar mills, nearly 25% mills have achieved sugar recovery of 11.05 to 12.35% during season 2016-17. These mills initiated steps to ensure minimum extraneous material with cane, minimize cane cut to crush duration and reduce post harvest sucrose losses. Sugar recovery and co-products production varies widely in sugar mills owned by cooperative or private sector. There are fluctuations in cane supply to mills which affects economic feasibility, profitability, cane price payment and outstanding arrears.

Development of data mining and presentation tools

Dimension modeling technique has been incorporated for development of data repositories consist of Facts and Dimension entities. Dimension are used to reference data under study corresponding primarily to places and time. Place dimension corresponds to the administrative hierarchy of a place *e.g.*, state, district, village, etc. Time dimension consists of temporal intervals such as year, month, week, day, etc. Facts are the metrics associated with attributes under study with reference to dimension.

Data sources for populating the data repository are either undocumented or available in secondary literature, and required cleaning, transformation, etc. before putting in the repository. Techniques adopted in data warehousing has been utilized for maintaining the quality of data. Data repository has been populated with following categories of facts (with respect to available dimension in the source) from various secondary sources (Location Coordinates, Region Type, Concerned Units, Normal Weather Data, Land Type & Land Use pattern, Soil Attributes, Irrigation Sources, Cropping Pattern, Sugarcane Production & Utilisation, Market & Technological Resources).

Web based applications are the modern and most suitable platform for accessibility to such data resources. Initiatives have been started to develop web applications for generating reports and analysis. These tools will work in Client-Server architecture, where data repository and applications will reside in database and web server.

Geographic information system of sugarcane and sugar in India

Evaluation of sugarcane genotypes for stable performance under various environmental conditions based on Genotype × Environment (GE) interactions for yield is a part of sugarcane varietal development programme. Based on the long term data analysis of cane yield (t/ha), CCS (t/ha) and sucrose (%), strategy has been applied for simultaneous selection for high yielding and stable genotypes under advanced varietal trials (AVT), Early and mid-late for different zones under AICRP on Sugarcane. Strategy involved simultaneous selection indices using Additive Main Effects and Multiplicative Interaction (AMMI) model.

On the basis of zonal varietal trials of AICRP(S) 2012-13 to 2014-15, twenty three genotypes which possessed qualities of high yield sustainability and low sensitivity in adverse environmental conditions were identified. These genotypes were more stable in different zones and were least affected by drought and water logging. Results revealed that simultaneous selection for high yield and stable genotypes were found high yielder and stable than widely adapted varieties of the zone (Table 8.4). These genotypes has been added in the National Hybridization Garden, Coimbatore for use as parents in sugarcane crossing programme.

Table 8.4. High yielding and stable genotypes of sugarcane

Zone	Early	Mid-late
Peninsular Zone	PI 07131 and VSI 08121	Co 07010, Co 07008, Co 08008 and Co 08009
East Coast Zone	CoA 09321	CoC 10337
North West Zone	Co 07023, Co 07025, CoPb 08212, CoPb 09181 and CoS 08233	CoPb 07213, CoPb 08217, CoPb 09214, CoH 08262, CoH 09264 and CoLk 09204
North Central and North Eastern Zone	BO 153 and CoP 08436	CoSe 08451 and CoP 09437

Impact of IISR technologies in sustaining sugarcane production in India

The project envisages to work out the impact of potential and identified six IISR developed technologies. Analysis for IISR developed sugarcane-cutter-planter was carried out during the period.

IISR developed sugarcane cutter planters are being manufactured by number of manufacturers in many States and are getting very good acceptance amongst all categories of sugarcane growers. Preliminary estimates revealed that the number of sugarcane cutter planters in

operation in India has increased substantially in almost all cane growing States of India. The sugarcane cutter planters have been purchased by all types of cane holdings. There are about 2.63 lakh cane growers who are using sugarcane cutter planters. These cutter planters are not only popular with the large holdings but also are very popular with the small holdings. About 62.75% of these categories of farmers are also using these machines, mostly on custom hiring basis.

The efficiency parameters were worked out. It is operated by small tractor (mostly 35 hp) and its effective field capacity is 0.2 ha/h (or 1 ha in 5 h) with field efficiency of more than 80%. The planter plant 1.6 ha per day (8 h). It performs all planting operations in one operation. Around 4 mandays are required to do the planting with ease. The planters have the provision for fertilizer and herbicide application too.

The use of this planting machine results in the saving of 35 mandays per ha in the planting of cane, and therefore, in the reduction of operational cost of cane cultivation per ha by ₹ 10,500 at a wage rate of ₹ 300/ day. The cost of operating a tractor along with sugarcane cutter planter is ₹ 400/h or ₹ 2000/ha along with ₹ 1200 due to four associated labour days. With these assumptions, the extent of cost reduction in sugarcane cultivation in India is to the extent of ₹ 182 crores (Table 8.5).

Table 8.5. Extent of cost reduction by using sugarcane cutter planter in India

Size group (ha)	Sugarcane Cutter Planter (Tractor drawn)	Average cane farm size (ha)	Extent of cost reduction (₹ in lakh)
Marginal (Below 1.0)	164911	0.36	6234
Small (1.0 - 1.99)	51037	0.77	4126
Semi-medium (2.0 - 3.99)	30111	1.25	3952
Medium (4.0 - 9.99)	14235	2.01	3004
Large (10 and above)	2528	3.53	937
All groups	262822	0.66	18214

CHAPTER 9

All India Coordinated Research Project on Sugarcane

Under AICRP on Sugarcane, the research programmes are being conducted in four disciplines viz., Crop Improvement, Crop Production, Plant Pathology and Entomology at 22 regular and 14 voluntary centres. In addition, technologies on improving crop and soil productivity through organic and inorganic sources of nutrients, management of binding weeds, improving germination through priming of cane nodes, management of white fly and mealy bug, mass multiplication of bio-agents of major insect pests, chemical control of rust disease, varietal resistance to red rot, smut and wilt diseases have been identified. New programmes, viz., integrated application of organic and inorganics for improving soil health and soil productivity, zonal evaluation of varieties at wider row spacing in Peninsular and East Coast Zones, screening of varieties for yellow leaf and pokkah boeng diseases, management of borers through pheromones, methodology for grading resistance of varieties against major insect pests, chemical control of early shoot borer were initiated. The physical and financial progress is monitored by the Project Coordinator and the Council. The physical progress is reviewed during Workshop/ Group Meetings.

Mandate

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

31st Biennial Workshop of AICRP on Sugarcane

The 31st Biennial Workshop of All India Coordinated Research Project on Sugarcane was organized at the Vastantdada Sugar Institute, Pune on November 16-17, 2016. The Inaugural Session was held under the Chairmanship of Dr. J.S. Sandhu, DDG (CS), ICAR, New Delhi. Shri Shivajirao Deshmukh, Director General, VSI, Pune accorded warm welcome of the delegates.

Dr. S.K. Shukla, Project Coordinator (Sugarcane) presented the Annual Progress Report of AICRP on Sugarcane for the year 2015-16. He informed that 115 genotypes had been identified under AICRP on Sugarcane till now. Out of these, 55 genotypes were released and notified for cultivation in different parts of country. Two sugarcane clones, CoPb 08212 (early) and CoP 09437 (Mid-late) were identified for North West Zone and North Central Zone, respectively. In Crop Production discipline, technologies of sub-surface drip irrigation for optimizing resource use efficiency and increasing productivity of sugarcane, use of organics in nutrient management, ethrel application for enhancing germination and growth of sugarcane were identified. In sugarcane protection, clean seed programme initiated after tissue culture combined with molecular diagnosis was found effective to rejuvenate degenerated sugarcane varieties. The main emphasis was given for development of improved sugarcane varieties, crop production and protection technologies.

Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow highlighted the achievements and new thrusts of

ICAR-IISR, Lucknow. He stressed the need of sugarcane research in multidisciplinary approach to improve the sugar availability. Dr. Bakshi Ram, Director, ICAR-SBI, Coimbatore, felt the need of development of early maturing varieties. Plateauing trend of sugar recovery and stagnant sugarcane productivity need focused attention. He mentioned that in Peninsular Zone, Co 09004 (early) recorded a 17.89% and 17.84% improvement over the best standard CoC 671 for sugar and cane yields, respectively.

Dr. R.K.Singh, ADG (CC), ICAR, New Delhi suggested Mission Oriented Programme for improving sugarcane development through ICAR-IISR, ICAR-SBI and VSI, Pune. He explained the need of enhancing sugar recovery, reducing cost of production, identifying climate resilient ISH and IGH genetic stocks, mechanization, bio-fertilizer and bio-pesticides use and efficient resource management through an integrated manner.

The Chairman, Dr. J.S. Sandhu, DDG (CS), ICAR, New Delhi emphasized the need on minimizing gap between potential and realized sugarcane yield on farmers' fields. In varietal development programme, thrust should be given on early maturing, high yielding and high sugar varieties with resistance to major diseases and pests to increase the farmers' income.

He suggested that rigorous efforts are required to improve the productivity and sugar recovery in times to come, keeping availability of natural resources in mind. He explained the need to focus on crop production and protection technologies, micro-irrigation systems, intercropping, crop diversification and distribution of quality seed among the farmers, soil analysis data, proper data recording by monitoring team, zone-wise standard package of practices and development of climate resilient sugarcane varieties. Monitoring of AICRP (S) experiments should be carried out through monitoring teams constituted for different zones and national monitoring team across the zones, as well.

Zonal Breeders Meet of AICRP (S)

All India Co-ordinated Research Project on Sugarcane organized Zonal Breeders Meet at ICAR-IISR, Lucknow on January 23, 2017. Sugarcane breeders from East Coast Zone, North West Zone and North Central and North East Zone and Senior Officers from Cane Development department of U.P. also participated in the meetings. Dr. S.K. Shukla, Project Coordinator (Sugarcane), AICRP(S) welcomed the participants. In the meeting, technical programme for crop improvement for the year 2017-18 has been finalized for East Coast Zone, North West Zone and North Central and North East Zones. In the meeting, the effective dissemination of technologies and for reducing the time period from genotype identification to varietal release to adaption in the farmer's fields was also discussed.

Dr. Bakshi Ram, Director, ICAR-SBI, Coimbatore informed the house that the meeting was held to promote best performing sugarcane clones in Initial Varietal Trials (IVT) to evaluate in Advanced Varietal Trials (AVT). This exercise saved one year in the varietal development cycle by skipping one year multiplication between IVT and AVT.

In the introductory remarks, Dr. A.D. Pathak reiterated that varieties played the major role in sugarcane cultivation and many biotic and abiotic stresses could be managed through appropriate varieties. Seed production programme for Bihar state was initiated by ICAR-IISR, Lucknow six years back for distributing quality seed. The number of state recommended sugarcane varieties are more in many states which should be reduced. In Bihar state, the number of recommended varieties was reduced to 15 from 66.

The chairman of the Session, Dr. R.K. Singh, ADG (CC), ICAR addressed the gathering and elaborated on improving sugarcane and sugar production in the current scenario. He thanked the Uttar Pradesh Cane Commissioner for his assurance to include the varieties which were notified by the Central Variety Release Committee for cultivation in the State. He emphasized the need for Public Private Partnership in developing and disseminating new technologies.

The address of Chief Guest was delivered by Shri V.K. Dwivedi, Cane Commissioner, Department of Sugarcane Development and Sugar Industry, Government of Uttar Pradesh. He informed that during the year 2016-17, U.P. may attain first position in sugar production in the country, overtaking Maharashtra state and thanked Dr. Bakshi Ram, on behalf of the U.P. Government, for developing Co 0238. The yield gap between tropical (81.4 t/ha) and sub-tropical (61.1 t/ha) regions opened new scopes for improving productivity in subtropical zone.

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 North West Zone (NWZ), among the nine entries evaluated in IVT (E), three entries viz., Co 13034, CoPb 13181 and CoS 13231 were selected based on juice sucrose % at 10 month, red rot resistance and field stand. These three entries will be

evaluated in AVT (E) I Plant during the year 2017-18.

- Among the 13 entries tested in IVT (ML), five entries namely, Co 13035, CoH 13263, CoLk 13204, CoPant 13224 and CoPb 13182 were selected for conducting AVT (ML) I Plant trial during the year 2017-18.
- In North Central and North East Zones, four entries were evaluated in IVT (E) and three entries viz., CoP 13437, CoSe 13451 and CoSe 13452 were selected for testing in AVT I Plant (Early) trial during 2017-18.
- Four entries were tested in IVT (ML) but none was found better than the standards in the North Central and North East Zones. Hence, there will be no AVT (ML) I Plant trial during the year 2017-18.
- In East Coast Zone, seven entries were evaluated in IVT (E) and three entries viz., Co 13023, CoA 14321 and CoC 14336 were selected based on juice sucrose % at 10 month, red rot resistance and field stand. These three entries will be evaluated in AVT (E) I Plant during the year 2017-18.
- Based on the juice quality traits, resistant to red rot and cane stand, out of twelve entries tested in IVT (ML), six entries namely, Co 13028, Co 13029, Co 13031, CoA 14323, CoC 14337 and PI 14377 were selected for testing in AVT (ML) I Plant trial during the year 2017-18.
- CoPb 13183 was reported as Highly Susceptible to red rot by Faridkot centre in IVT as against the resistant reaction reported for the clone when it was proposed for inclusion in ZVT by the same centre. The anomaly in red rot reaction must be avoided and extreme care must be taken in red rot evaluation.
- All the centres must present the juice quality parameters at 8th and 10th month of the IVT (Early) entries and 10th month of IVT (Mid-late) entries during the zonal breeder's meet.
- Shortage of seed materials of CoS 15231 was reported by seed multiplication centre, Karnal. Faridkot, Sriganganagar and Kota centres will lift the entry from Karnal. Shajahanpur will supply the entry to Pantnagar, Lucknow, Muzaffarnagar and Kapurthala.
- Varietal mixture was reported in the seed materials of CoLk 15202 at Karnal. Hence, the entry will not be sent by Karnal to any of the NWZ centres. Lucknow will send the seed materials of CoLk 15202 to all participating centres directly for multiplication.
- All the existing pathotypes of red rot to be deposited with ICAR- National Bureau of Agriculturally Important Microorganism, Mau for getting accession number.
- Breeders from all the participating centres must attend the zonal breeders meet for better discussion.

Varietal Identification Committee Meeting

Varietal Identification Meeting was held under the Chairmanship of Dr J.S. Sandhu, DDG (Crop Science), ICAR, New Delhi on Nov. 16, 2016 at VSI, Pune during 31st Biennial Workshop of AICRP on Sugarcane and 2nd meeting was held on March 20, 2017 at Krishi Bhawan, New Delhi.

Salient Research Achievements

Identification of sugarcane varieties

Two varieties of mid-late group *i.e.*, CoLk 09204 (Ikshu-3) and Co 09022 (Karan-12) for the North West Zone and two varieties of early group *i.e.*, Co 09004 (Amritha) for Peninsular Zone and UP 09453 for the North Central & North East Zone were identified for release.

A total of 25 Zonal Varietal Trials (14 in early and 11 in midlate) were conducted. There were 8 IVT and 17 AVT trials. A total of 66 entries in early group and 68 entries in midlate group were evaluated of which 17 in early and 11 in midlate were found promising.

Fluff Supply Programme

This year 611 parental clones were planted in NHG, Coimbatore. However, only 356 parental clones flowered. This year flowering was less than 58.26% against the high flowering of 85.81% in the previous year. Twenty three centres made 473 station crosses and 17 selfs. In addition, 32 proven crosses for four different zones, 219 general collections (GC) and 21 poly crosses (PC) were also made.

Technologies developed and recommended

Agrotechnologies

- Addition of 20 t FYM/ha along with inorganic fertilizers on the basis of soil test, crop response for targeted yield may be recommended for both plant and ratoon crops. Response of bio-fertilizers (*Azotobacter*/ *Acetobacter*/ *Azospirillum*/ PSB) was better in Peninsular Zone.
- Sett treatment with ethrel @ 50 ppm accelerated as well as enhanced germination. Spraying of GA_3

(35 ppm) at tillering enhanced cane yield substantially.

- Sub-surface drip irrigation for sugarcane has shown its potential in saving irrigation water and raising the cane yield.

Disease and Insect-pests management

- All the centres have been advised to conduct experiment under PP 14 with additional new set of differentials *i.e.*, Co 7805, CoSe 95422, Co86002, Co 86032 and CoV 92102 as suggested last year.
- At some centres, the collection of isolates of red rot pathogen is very limited. There is an urgent need to collect more number of samples to have a clear cut race picture of the area.
- To manage YLD, all the centres should take healthy seed nursery programme. The centres should advice the sugar Industry that heat treatment alone is not effective against the viral pathogens.
- All lotted centres should collect the planting material of 27 ISH lines to test for their resistance under PP 23.
- After a long gap, leaf scald has been noticed in Andhra Pradesh probably due to introduction of varieties through unknown sources. The sugar industry should desist from bringing materials from other areas to avoid inadvertent introduction of leaf scald and other diseases.
- As per the recommendation of QRT, all the centres may procure 'Mechanized Sett Treatment Device' developed by ICAR-SBI, Coimbatore for seed nursery programme and disease management.
- Installation of sex pheromone traps @ 27/ha coinciding with the emergence of moths is recommended for the management of early shoot borer, top borer, internode borer and stalk borer (Specific septa should be used as per occurrence of different species of moths).
- Soil application of chlorantraniliprole 0.4 G @ 22.5 kg/ha at the time of planting and/or 60 DAP or spraying of chlorantraniliprole 18.5 SC @ 375 ml/ha at 30 and/or 60 DAP was found effective for the management of sugarcane early shoot borer.

CHAPTER 10

Intellectual Property and Technology Management

IP management

Trademark

Registration of Institute logo as trademark was carried out with the Indian Patent Office, New Delhi vide Application/ Registration No. 3253310 on May 9, 2016.

Patent

A patent on "Technology for priming sugarcane planting material, its packaging, transportation and certification" was filed with the Indian Patent Office, New Delhi and FER is awaited.

Commercialization of technologies

Technology of IISR Model Jaggery Unit was commercialized to different firms/entrepreneurs as per details given below:

Name of technology transferred / adopted	No of units	Address of farmers/ entrepreneurs/ manufacturers
IISR 3-pan jaggery unit	03	• IISR Regional Centre, Motipur, Bihar • Shri Jagtar Singh, Amritsar, Punjab • M/s Bodhi Tree Exim Pvt. Ltd., Bodhgaya
Moulding frame	45 sets	• Shri Rajendra Verma, Faizabad • Shri Ram Kumar Kharab, Hansi, Hisar • Shri Kulwant Singh, Kurushetra • Shri Jagtar Singh, Amritsar • Shri Suraj Kumar, Chinhat, Lucknow • Shri Kaushal Singh, Gurdaspur • Shri Yaqoob Ahmed, Gurdaspur • Shri Himanshu Gangwar, Farrukhabad • Shri Manjeet Singh, Gurdaspur • Shri Swami Indreshanand, Jalandhar

Outreach activities

Programme organized for technology commercialization/ transfer	Number of participants	Venue
Jaggery entrepreneurship development	500 farmers	ICAR-IISR, Lucknow & ICAR-IISR, Regional Centre, Motipur (Bihar)
Follow up visits	Three visits	Firms having MOU with the Institute
All Scientists of the Institute	At least one visit by each of 13 teams per quarter	Sitapur, Hardoi, Barabanki, Raebareli

Capacity building in IP management

Programme attended	Organized by	Date of programme
Workshop on Bio-Entrepreneurship and Bio-Enterprise Creation	Biotech Park, Lucknow	September 16-17, 2016
FICCI Millennium Alliance in Lucknow	FICCI & USAID	January 28, 2017
Workshop on Funding Opportunities for Start-ups	ICAR-IARI, New Delhi	March 01, 2017

Training/Workshop organized

Programme organized	Date	Participants (No.)
Technical Expo 2016	April 29-30, 2016	200
Workshop on Institute Technology Management	March 30, 2017	125

Other activities

- A proforma for reviewing of MoAs has been prepared and sent toall contracting parties having the agreement with the Institute.
- Six contract research projects were signed during the period.

CHAPTER 11

Outreach Programmes and Transfer of Technology

Entrepreneurship development for sugarcane seed production

Seed cane crop of seven selected varieties viz., CoLk 94184, CoLk 9709, CoPK 05191, Co 0118, Co 0238, Co 05011 and CoH 128 was planted on factory farm and farmers' fields in Sitapur, Barabanki and Lakhimpur districts of U.P.; and in factory farm of Hasanpur sugar mill, Hasanpur, Bihar. A total of 47 seed cane plots in 14 ha area was maintained in 8 villages (Table 11.1). The average yield obtained for seed cane crop of different varieties raised during last season were 104, 112, 122, 125, 130, 95 and 92 t/ha for varieties CoLk 94184, CoLk 9709, CoPK 05191, Co 0118, Co 0238, Co 05011 and CoH 128, respectively (Table 11.2). A total of 1667.80 tonne seed cane was produced out of which 66% was utilized as seed material and rest of the cane was used for crushing (Table 11.2). The average net profit recorded for seed cane crop was ₹ 2,86,159/ha, however, it varied between ₹ 2,15,340 and ₹ 3,48,750/ha.

Table 11.1. No. of plots & area under seed cane crop of each variety (2016-17)

Sugarcane variety	No. of plots	Area in ha
CoPk 05191	10	3.50
Co 0118	10	3.00
CoH 128	2	0.20
CoLk 94184	5	2.00
Co 05011	4	0.80
CoLk 9709	6	1.20
Co 0238	10	3.30
Total area	**47**	**14.00**

In the project area, the cane acreage (Biswan, Sitapur) under early varieties increased from 13,357 ha in 2014-15 to 29,788 ha in 2016-17, which was 123.01% increase in cane area under early group (Table 11.3). This led to quantum jump in average yield, sugar recovery and profit realization by the sugar mill. The

Table 11.2. Seed cane yield, seed cane production & utilization and economics of seed cane crop

Variety	Average yield (t/ha)	Total seed cane produced (t)	Seed cane utilization pattern (in t)		Return (₹/ha)			Net profit (₹/ha)
			For seed multiplication	Crushing	Seed @ ₹ 3900/t	Crushing @ ₹ 3150 & ₹ 3050/t	Total	
CoPK 05191	122	427.00	213.50 (50%)	213.50 (50%)	237900	192150	430050	310050
Co 0118	125	375.00	300.00 (80%)	75.00 (20%)	390000	78750	468750	348750
CoH 128	92	18.40	12.88 (70%)	05.52 (30%)	251160	84180	335340	215340
CoLk 94184	104	208.00	156.00 (75%)	52.00 (25%)	304200	81900	386100	266100
CoLk 9709	112	134.40	107.52 (80%)	26.88 (20%)	349440	70560	420000	300000
Co 05011	95	76.00	53.20 (70%)	22.80 (30%)	259350	86925	346275	226275
Co 0238	130	429.00	257.40 (60%)	171.60 (40%)	304200	163800	468000	348000
	111.43	**1667.80**	**1100.50 (65.99%)**	**567.30 (34.01%)**	**286806**	**119353**	**406159**	**286159**

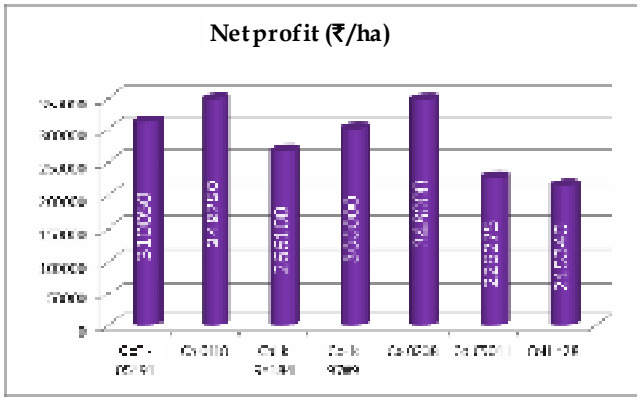
Production cost @ ₹ 1,20,000/ha (considered)

Table 11.3. Cane area under Early, Mid-late, Rejected varieties and sugar recovery in Biswan, Sitapur

Year	Sugarcane area						Sugar recovery
	Early		Mid-late		Rejected		
	ha	%	ha	%	ha	%	(%)
2012-13	8001	24.27	23772	72.10	1196	3.63	9.78
2013-14	9736	35.11	17531	63.22	465	1.68	10.17
2014-15	13357	49.79	13238	49.34	233	0.87	10.38
2015-16	22677	68.38	4596	13.86	5889*	17.76*	12.40
2016-17	29788	88.68	2990	8.90	812	2.42	11.65

*Cane variety CoSe 92423 (H~5600 ha) was under mid-late group in 2014-15, which was notified by UP Govt. under rejected in 2015-16.

increase in area under early variety and sugar recovery may be attributed to a great extent to the interventions introduced in the sugar mill area by the ICAR-IISR.



Net profit for seed cane crop of different varieties (₹/ha) in Biswan, Sitapur

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

Data on timeline of sugarcane development, cropping systems and ITKs from two villages viz., Kathaua and Balpur of Balrampur Chini Mill reserved zone were collected. A total of 50 farmers, 10 KIs and 10 sugarcane development personnel were contacted. The prevailing cropping systems were Paddy-Mustard-Sugarcane-Ratoon, Paddy-Wheat-Sugarcane, Paddy-Lentil-Sugarcane. ITKs like soil fertility assessment by observing crops & clod formation, keeping herds of animals in the fields at night for many consecutive days like 15 to 30 days to tap dung and urine *in situ* for soil fertility improvement, indigenous method of sowing by using desi plough, overnight soaking of seed cane, use of neem cake 50 kg / acre at the time of planting to control termite, summer ploughing & digging with spade for weed control, irrigation of seed cane crop before 7 days of harvesting for better germination, mulching of field after planting with cattle and agricultural waste for early germination and moisture conservation, beating of empty tins, vessels, etc., turn by turn by group of people for locust control and use of ash for control of gundhi bug were documented.

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

The appraisal of four villages namely, Jamalpur, Jananahkheda (Block Gola) Konauthia (Block Lakhimpur) and Munda Pasi (Block Kumbhi) of Lakhimpur Kheri district was carried out. The data were collected from key informants, progressive farmers and elderly persons. About 90% area of the village was cultivable and 10% under community uses such as pasture, drainage, forest *etc*. The topographic information revealed that about 85-90% land was plain, soils were loamy (46.75%), clay loam (42.5%) and sandy (12.5%). The soil fertility level was medium to low, however, in some pockets, it was high. The major crops grown were paddy in *kharif* and wheat in *rabi* mostly for their own consumption and partially for sale. The cropped area under paddy and wheat were 26.25% and 23.75%, respectively. In pulse crops, lentil was grown in *rabi* covering about 3-5% area. Under oilseed crops, mustard was grown during *rabi* covering an area of 5-10%. Sugarcane was grown in 75% of the total cropped

area. Most of the sugarcane (~90%) was supplied to sugar mills and remaining was used as seed cane, manufacturing of *Khandsari*, etc. Mentha a cash crop was also cultivated by some farmers during summer covering about 1.5% area of their holdings. Farmers also had animal husbandry for the purpose of milk production and cultivating fodder crops such as berseem in *rabi*, *jowar/bajra* in summer and *kharif* and they allocated about 0.5-1% area of their holdings. Feeding of sugarcane tops was also found in practice. The cultivation of vegetables such as okra, cucurbits, cole crops, potato was carried out in very small area (0.5-1%) for own consumption as well as partially for sale in local markets.

The prevailing cropping pattern revealed that farmers were growing these crops in order of sequence *i.e.*, one crop sequence –sugarcane; two crops sequence paddy-wheat, paddy-sugarcane while, in three crops sequence paddy –wheat-sugarcane-wheat, paddy-mustard-sugarcane-wheat. Some of the farmers (3-4%) were also intercropping potato and mustard with sugarcane. The problems associated with productivity of crops were insect pests and diseases incidences (I rank), occurrence of droughts (II ranked), low fertility level (III rank) slow infiltration/compact soil (IV rank) and water logging (V). The productivity limiting factors associated with sugarcane cultivation were identified and ranked in order of importance were damage by wild animals (blue bull, boars) stray cattle, etc, climatic variability resulting in erratic rainfall, droughts, floods, storms and piecemeal harvesting of plant crop, non-vacation of fields limiting planting of autumn cane, delayed planting in spring season due to late harvest of wheat crop, non-availability of inputs at proper time and depletion of ground water.

Mera Gaon Mera Gaurav

Thirteen multidisciplinary teams of the scientists of ICAR- IISR, Lucknow adopted 63 villages under the scheme "*Mera Gaon Mera Gaurav*" in five districts, namely Sitapur-43, Faizabad-5, Hardoi-5, Raebareli-7, and Barabanki-3. At the outset, each team contacted the farmers by paying personal visits at their home and fields which enabled them in rapports building as well as understanding the prospects of the villages after acquiring baseline information from the key informants and resource persons of the villages. *Kisan gosthies*/ meetings were organized in all the 63 adopted villages by paying 15 visits of team scientists. The scientists-farmers interaction helped in ascertaining utmost important issue of agricultural importance with active participation of 4,596 farmers in the different villages. The mobile user farmers were identified to harness rapid delivery of agricultural messages and through this, 524 farmers were benefitted by making delivery of 330 important messages. As much as 399 copies of the literature were provided to 399 farmers as literature support was found playing important role in transfer of agricultural technologies for strong conviction in adoption of technologies. The scientists facilitated 711 farmers in getting new varieties, seed, information on technologies and inputs through which approximately 896 hectare area was brought under the cultivation of crops. Besides, awareness was created among 1,510 farmers about new varieties, seeds, technologies and source availability in the adopted villages. The interface with the organizations such as sugar mills, *Krishi Vigyan Kendra*s (KVKs), Cane Developments Councils, District Agricultural Departments, NGOs was promoted through which 1088 farmers were benefitted as a result of having linkages with these organizations. Details are given in Table 11.4.

Table 11.4. Activities under *Mera Gaon Mera Gaurav* Scheme

Activity details	Number	No. of beneficiaries
Visit of Scientists' team to hasten lab to land process, identification of problems, farm advisory and information	15	889
Organising *Kisan Gosthies*/meetings	11	1087
Mobile advisory services for delivery of important messages	330	524
Literature support provided to farmers on various subject matter relevant to farmers.	329	399
Facilitated farmers in acquiring of quality seed, planting materials, information on technology and inputs.	As per farmers' need	711 farmers 896 ha. area
Created awareness about new varieties, seeds, information on technology and inputs, etc.	-do-	1510
Linkages created with organizations such as sugar mills, *Krishi Vigyan Kendra* (KVKs), District Agricultural Departments, Cane Development Councils, NGOs, Input Agencies, etc.	-do-	1088

Frontline demonstrations

For fast spread of newly released sugarcane varieties, FLDs on seed cane production technology was conducted at farmers' fields in Uttar Pradesh and Bihar. Seed cane crop of varieties CoLk 94184, CoPK 05191, Co 05011, CoH 128, Co 0118, CoLk 9709, Co 0238, Co 0232 and Co 0233 was raised on 15 ha area with recommended package of practices.

Demonstration on intercropping with autumn and spring sugarcane was conducted on farmers' fields in Sitapur and Lakhimpur districts of U.P. covering 15 ha area. This activity was funded by Ministry of Agriculture and Farmers Welfare, Govt. of India under NFSM.

Frontline demonstrations of IISR tractor operated ratoon management device were conducted at farmers' fields in Sitapur district of Uttar Pradesh in 10 ha covering 20 farmers.

On-station demonstration

To showcase the cane production technology to dignitaries and visitors, on-station demonstration in one ha area was laid out in Technology Park (Field No. E-40). Planting methods, intercropping with sugarcane, IPM, cane node technique, plant growth regulator and cane varieties were demonstrated.

1. Deep furrow sugarcane cutter planter

Demonstrations of tractor operated deep furrow sugarcane cutter planter were conducted at farmers' fields in Sultanpur, Bahraich, Faizabad, Hardoi and Muzaffarnagar districts of Uttar Pradesh in 15.9 ha field covering 17 farmers.

2. Tractor operated paired row trench planter

Demonstrations of tractor operated paired row/ trench planter was conducted at farmers' fields in

On-station demonstration of deep furrow sugarcane cutter planter

Sitapur, Lakhimpur Kheri and Hardoi districts of Uttar Pradesh in 17.6 ha area. Equipment was used to plant one pair of sugarcane at 30 cm row spacing in deep and wide furrow (trench). Cane was planted under 30:120 cm row geometry.

ICAR-IISR interventions for doubling farmers' income

The ICAR-IISR introduced many interventions like trench planting, seed cane production, intercropping, ratoon management, water saving irrigation techniques etc., in farmers' fields in Sitapur, Lakhimpur and Muzaffarnagar districts of U.P. Farmers doubled their income from sugarcane based production system. Now fields of those farmers in Sitapur district have emerged as Model farm and many groups from different states have visited those model farms and learned techniques of "More income - Per crop". A progressive farmer, Shri Aditya Nath Singh, Biswan, Sitapur who adopted IISR interventions was honoured with Innovative Farmer Award from Hon'ble Union Minister of State for Agriculture and Farmers' Welfare, Govt. of India on March 17, 2017 in New Delhi.

Kisan Mela and Gosthi organised

A *Kisan Mela* was organized on March 26, 2017 at Manpur Village of Biswan Block in Sitapur District of U.P. The *Mela* was inaugurated by Dr. J.S. Sandhu, DDG (Crop Science), ICAR and Dr. R.K. Singh, ADG (CC), ICAR was special guest in the event. Large number of farmers, development officials, and sugar mill personnel participated in the *Mela*. At this occasion, an exhibition on cane production technology, agri chemicals, agri equipments was oraganised in which research institutes, development department, manufacturers, KVKs and sugar mills showcased their products and services. *Vaigyanik-Krishak Parichacha* was also organized for the benefit of the participating farmers.

Annual Convention and Technical Expo 2016 Organised

Two days Annual Convention of North Indian Sugarcane and Sugar Technologists' Association (NISSTA) and Technical Expo 2016 was jointly organized by ICAR-IISR, Lucknow and NISSTA on April 29-30, 2016 at IISR, Lucknow.

Shri Pravir Kumar, IAS, Agricultural Production Commissioner, Govt. of Uttar Pradesh was the Chief Guest in the Inaugural Session. On this occasion, a Technical Expo to showcase the latest innovations done by the industry, research institutes and supporting organizations was also organized. More than 250 delegates participated in this Convention. .

Organisation of Technology and Machinery Demonstration *Mela*

Technology & Machinery Demonstration *Mela* was organized at ICAR- IISR, Lucknow on February 10, 2017. It was jointly organized by IISR, Lucknow Centre of AICRP on Farm Implements & Machinery and Post Harvest Engineering and Technology. Total participants were 400, mainly farmers from Uttar Pradesh, Madhya Pradesh and Punjab.

***Kisan Mela* and *Goshthi* organized**

Kisan Mela/Goshthi	Venue	Date
Kisan Mela	Jamshedpur	April 19-May 1, 2016
Agri Fair-cum-Exhibition for demonstration of improved agricultural technologies and innovations	ICAR Research Complex for Eastern Region, Patna	May 28, 2016
Purvanchal Krishi Mela & Foundation Stone Ceremony of KVK, Gorakhpur	KVK, Gorakhpur	October 22, 2016
Kisan Mela organized by NEFORD	Dumraon, Mau	November 2-4, 2016
Krishi Goshthi & Foundation Stone Ceremony of Jaggery Processing Training Unit	KVK, Piprakothi	November 7, 2016
Animal Science Exhibition	KVK, Chaukimafi, Gorakhpur	November 15, 2016
Kisan Mela	ICAR-IIFSR, Meerut	November 28, 2016
Kisan Mela	Dr. RPCAU, Pusa	December 3, 2016
National Farmers' Fair	ICAR-IIVR, Varanasi	January 26-27, 2017
Imparting training to farmers/ entrepreneurs for jaggery making	ICAR-IISR RC, Motipur	February 3, 2017
Unati Krishi Mela	ICAR-IARI, New Delhi	March 15-17, 2017
Krishi Mela	UPCSR, Shahjahanpur	March 20, 2017

Dr. R.P. Singh, Honourable Member, Governing Body, ICAR New Delhi visited the *Mela*. Dr. Singh stressed the need of transfer of technology from laboratory to the actual users *i.e.*, farmers. Dr. A.D. Pathak, Director, IISR elaborated the efforts made by the institute for popularization of technologies. Dr. A.K. Singh, Head, Division of Agricultural Engineering, welcomed the participants and gave introductory remarks. He explained the details of machinery/technology developed at IISR. Dr. S.I. Anwar, I/c Jaggery Unit and Dr. Dilip Kumar, PI, PHET highlighted the importance of jaggery and ongoing research on jaggery making.

Visit of Dr. R.P. Singh, Honourable Member, Governing Body, ICAR during the *Mela*

Field demonstration of IISR deep furrow multitasking sugarcane cutter planter

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 equipment exhibited and demonstrated.

Conducting farmers and students visit

During the year 2016-2017, about 2,000 farmers from different States of the country visited the Institute and during their visit, they got acquainted with practical aspects of sugarcane technologies developed by the Institute. Similarly, about 500 UGs/PGs students and teachers from SHIATS, Allahabad; BHU, Varanasi; AMITY, Lucknow; IT College, Lucknow and other institutions also visited the Institute.

Transfer of technology including FLDs

- Installation of a Jaggery Unit at KVK, Piprakothi (Bihar). The Foundation Stone was laid by Hon'ble Minister of Agriculture and Farmers' Welfare, GoI, Sh. Radha Mohan Singh on November 7, 2016.

Foundation stone laying by Hon'ble Minister of Agriculture and Farmers' Welfare, GoI, Shri Radha Mohan Singh

- Supplied jaggery moulding frames to different farmers.
- Improved jaggery making technology was demonstrated to farmers/visitors visiting jaggery unit.

Exhibitions organized

Date	Place	Organizer
November 03, 2016	Maunath Bhanjan (U.P.)	Nand Educational Foundation for Rural Development, Aliganj, Lucknow, Uttar Pradesh
November 12-16, 2016	Pune (Maharashtra)	VSI, Pune
November 26-28, 2016	ICAR-IISR, Lucknow (U.P.)	Vibrant Uttar Pradesh by CARD
November 07, 2016	Piprakothi, Motihari (Bihar)	Dr RPCAU, Pusa & ICAR-IISR, Lucknow
November 22-26, 2016	ICAR-IARI, New Delhi	International Agronomy Congress, Indian Society of Agronomy
October 23-24, 2016	Gorakhpur (U.P.)	ICAR-ATARI, Kanpur
January 27-31, 2017	Raipur (Chhattisgarh)	*Krishi Samridhi–Rashtriya Krishi Mela* by Chhattisgarh Government
February 16, 2017	ICAR-IISR, Lucknow (U.P.)	ICAR-IISR, Lucknow on Foundation Day
March 15-17, 2017	ICAR-IARI, New Delhi	Ministry of Agriculture and Farmers Welfare, Govt. of India (*Krishi Unnat Mela*)
March 26, 2017	Biswan Sugar Factory, Sitapur	ICAR-IISR, Lucknow

TV/Radio talks delivered

Title	T.V./Radio programme	Name of Scientist	Date of recording/ telecast
Grishmkalin Ganna Utpadan	Krishi Doordarshan, Lucknow	Dr. A.K. Sah	April 6, 2016
Live Phone in Programme - Sugarcane	Akashwani, Lucknow	Dr. A.K. Sah	July 20, 2016
Vikas Sanwad - Khandsari Udhyog	Akashwani, Lucknow	Dr. A.K. Sah	November 21, 2016
Live Phone in Programme : Sugarcane	Akashwani, Lucknow	Dr. A.K. Sah	March 29, 2017
Sugarcane Expert	Krishi Doordarshan, Lucknow	Dr. A.K. Sah	March 28, 2017
Talk on *Ganne Ki Phasal Mein Keet Rog Prabandhan*	Akashvani, Lucknow	Dr. M.R. Singh	August 2, 2016
Talk on Insect pests and diseases of sugarcane	Hello DD *Kisan Karyakram* at New Delhi	Dr. M.R. Singh & Dr. S.K. Duttamajumdar	August 31, 2016

Krishi Vigyan Kendra, ICAR-IISR, Lucknow

On farm testing/trials (OFTs): OFTs are most important mandatory component of KVK under which recently developed technologies or varieties are evaluated in specific agro climatic condition for future recommendations or popularization. Following nine OFTs were conducted pertaining to various disciplines as per identified major thrust areas :

- Performance of organic farming in rice crop
- Evaluation of newly introduced HYV of wheat
- Increasing cropping intensity through diversification in Lucknow district
- Integrated disease management in vegetable pea
- Management of leaf webber in mango orchard
- Evaluation of biological practices in potato
- Evaluation of biological practices in mango
- Evaluation of improved mango harvester for picking
- Availability of green fodder to milch animal round the year

A. Frontline Demonstration: FLDs on oilseeds, pulses and other crops or enterprises were conducted. A total of 702 demonstrations at farmers' field in an area of 123 ha in which in *rabi* season, oilseeds covered 5.0 ha area, pulses 61.0 ha area, other crops like vegetables, cereals and fodder crops covered 48.0 ha area in addition to animal health management through vaccination and deworming of 1,000 animals (Buffaloes and Cows) were carried-out.

B. Training programmes: *Krishi Vigyan Kendra* offered 92 training courses for participating farmers, farm women on various topics with an objective to improve skill and upgrade their knowledge about developed and potent technologies. All training programmes were skill oriented and conducted following the principles of "Learning by doing". A total of 1840 participants (1440 Male, 400 Female) attended the programme.

C. Extension programmes

Activity	No. of programmes	No. of farmers	No. of extension personnel	Total
Advisory services	135	-	-	-
Diagnostic visits	18	155	-	155
Field day	8	310	-	310
Group discussions	15	180	20	200
Kisan goshthi	6	800	-	800
Film show	25	500	16	516
Kisan mela	1	675	25	700
Exhibition	5	6500	30	6530
Scientists' visit to farmers field	125	1225	-	1225
Farmers' seminar/workshop	1	500	25	525
Method demonstrations	24	445	-	445
Celebration of important days	4	175	-	175
Animal camp	01	80	2	82
Special day celebration	1	50	-	50
Total	**369**	**11625**	**118**	**11743**

Other Extension Programmes

Particulars	Number
Extension literature	18
Newspaper coverage	26
Popular articles	32
Radio talks	24
TV talks	18
Animals treated in health camps	50
Total	**168**

D. New initiatives

- Established a low cost mushroom unit at KVK, Lucknow
- Evaluation of different organic products in horticultural crops
- Large scale demonstration of pulse crop
- Introduction of exotic vegetables as high value crops
- Popularization of intercropping of turmeric in mango orchards
- Plastic mulch in vegetable cultivation
- Pruning and staking in tomato cultivation
- Popularization of perennial grasses as fodder
- Value addition in different horticultural crops
- Established ICT lab at KVK, Lucknow

E. Produce of KVK

Item	Name of the crop/ Entrepreneur	Quantity
Seed	Pigeonpea	40.0 q
Seedlings	Broccoli, Onion, *Kharif* Onion, Marigold and Tomato	7,30,000 No.
Planting material	Turmeric	6.0 q
	Colocasia	3.0 q
Others	Vermicompost	60.0 q
	Pickles	54.0 kg
	Button mushroom	34.0 kg
	Slips of fodder grasses	3250 No.

Success Stories

1. Success story of a rural youth who introduced "Exotic vegetables cultivation in Lucknow district"

Born on December 11, 1975, Shri Ramesh Verma, resident of Village and Post- Kasimpur Biruha, Gosaiganj, Lucknow received the education upto intermediate. Sh. Verma is cultivating exotic vegetables like Broccoli, Red cabbage, China cabbage, Ice berg, Lettuce (Red and Yellow), Salary, Leak, Cherry tomato, Basil, Lemongrass and Parsley in his field under the supervision of Scientists of KVK, Lucknow. KVK linked him to sold out these vegetables at the different multinational retailers and hotels like WallMart, Bharti, Big Basket, Big Bazaar, Spencer, Hotel Clarks Awadh, Hotel Taj etc. Cost of cultivation of these vegetables grown in an area of 0.506 ha was ₹ 26,400.00 which gave gross and net returns of ₹ 3,36,500.00 and ₹ 3,10,100.00 respectively, with the benefit : cost ratio of 11.75.

Exotic vegetables grown by Sh. Ramesh Verma through training and technical guidance from the KVK, Lucknow

2. Success story of beekeeping

Shri Brijesh Verma, aged about 46 years, resident of Village-Madarpur, Post Office- Kiwali, Block- Gosaiganj, Lucknow is a post graduate, who adopted entrepreneurship of bee keeping in his 0.4 ha land holding, under the supervision of the Scientists of KVK, Lucknow. Sh. Verma sold 2,50,000 kg of honey @ 150/- per kg, apart from wax, pollen and new colonies of the honey bee. During the year 2016-17, total income of Sh. Verma was ₹ 3, 97, 60,000/-.

3. Success story of prosperity from flower cultivation: Gladiolus

Sri Ramasrey is a resident of Village-Jagatapur, Block-Malihabad, District-Lucknow. He is cultivating Friendship Pink, Friendship white, Eurovision, Oscar, Picardy, Regency, Rashmi, Sadabahar, White Prosperity, Sylvia and Nova Lux varieties of Gladiolus flower in his land holding of 1.5 ha. He invested ₹ 6,93,750/- on the cultivation of Gladiolus flowers and earned ₹ 9,00,000/- during the year 2016-17.

CHAPTER 12

Services to the Industry

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, pesticides, 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 in 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)
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
Evaluation of different potassic fertilizers in sugarcane	CSIR-CSMCRI, Bhavnagar	Dr. V.P. Jaiswal, Dr. S.K. Shukla, Dr. C. Gupta & Dr. Ishwar Singh	March 2016	March 2017	10.0
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

National level training for cane managers

A 15-days training on Sugarcane Management and Development for cane development personnel of sugar mills was organized from July 1-15, 2016. Twenty cane managers/officers from U.P, Bihar and Haryana participated in this training. The major objective of this training was to accelerate large-scale adoption of sugarcane technologies in sugar mill zone areas by grooming & developing cane managers/officers of sugar mills into "torch-bearer" of IISR technologies and to spread the technologies with expected dividends of high sugarcane and sugar productivity.

A total of 16 residential skill development training for different clientele groups was organized in which 7071 farmers, entrepreneurs, student, 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 induding jaggery making. The break up of training is as Table 13.1.

Table 13.1. Skill development training organized

S. No.	Name of training	Topic	Duration	Sponsoring agency	No. of partici-pants
1	2 days Farmers' Training	Integrated pest management in sugarcane	April 21-22, 2016	Institute for Rural Development, Madurai, Tamilnadu	20
2	2 days Farmers' Training	Sugarcane production & management	May 11-12, 2016	Dr. Punjabrao Deshmukh Jaggery Cluster, Bhandara, Maharashtra	35
3	21 days student training	Advances in sugarcane production technology	May 30-June 19, 2016	Students of Mewar University, Rajasthan	25
4	5 days student training	Advances in sugarcane production technology	June 20-24, 2016	Students of BHU, Varanasi	39
5	15 days National Training	Sugarcane management and development	July 01-15, 2016	Sugar mills	20
6	3 days Farmers' Training	Integrated crop management in sugarcane	July 26-28, 2016	ATMA Vellore, Tamil Nadu	20
7	3 days Farmers' Training	Integrated crop management in sugarcane	July 26-28, 2016	ATMA Tirunelveli, Tamil Nadu	20
8	3 days Farmers' Training	Integrated crop management in sugarcane	August 10-12, 2016	Assistant Director of Agriculture, Sathankulam, Tuticorin, Tamilnadu	20
9	3 days Farmers' Training	Improved technology of sugarcane production	November 2-4, 2016	ATMA, Narsinghpur, M.P.	27
10	5 days officers and staff training	Improved technology of sugarcane production	December 12-16, 2016	Department of Agriculture, Govt. of U.P.	35

11	2 days National Training	Improved cane varieties and planting methods for higher yield of sugarcane	January 17-18, 2017	DAC, Ministry of Agriculture and Farmers' Welfare, Govt. of India	25
12	2 days National Training	Integrated nutrient and weed management in sugarcane	January 19-20, 2017	DAC, Ministry of Agriculture and Farmers' Welfare, Govt. of India	25
13	2 days National Training	Intercropping options in sugarcane for enhancing system productivity and profitability	January 23-24, 2017	DAC, Ministry of Agriculture and Farmers' Welfare, Govt. of India	25
14	2 days National Training	Integrated pests and disease management in sugarcane	January 27-28, 2017	DAC, Ministry of Agriculture and Farmers' Welfare, Govt. of India	25
15	2 days National Training	Mechanization and post harvest management in sugarcane	January 30-31, 2017	DAC, Ministry of Agriculture and Farmers' Welfare, Govt. of India	25
16	One day Farmers training	Improved technology for sugarcane production	March 26, 2017	DAC, Ministry of Agriculture and Farmers' Welfare, Govt. of India	700

In addition to above, 57 nos. of one day training and visit programme was organized at the Institute in which more than 2,000 farmers, students, development personnel acquired latest know-how in scientific cane cultivation practices.

Skill development training on natural farming

Under *Pandit Deen Dayal Upadhyaya Unnat Krishi Shiksha Yojana* launched by Ministry of Agriculture and Farmers Welfare, Govt. of India, 10 nos. of 5 days training was organized in *Mullahikheda*, Lucknow and *Hariharpur*, Amethi. In farmers to farmers training mode, information in natural farming and cow based zero budget farming was provided to the participating farmers. In each training, 30 farmers participated, thus, a total of 300 farmers were trained in natural farming.

Entrepreneurship training conducted

To develop entrepreneurial ability of cane growers in cane seed production, multiplication and marketing, entrepreneurship trainings were organized in the months of September, October, December and March in cane growing areas of Uttar Pradesh and Bihar.

To develop entrepreneurial ability of agri graduates and progressive farmers in jaggery production especially in Bihar and Eastern Uttar Pradesh, the Institute has established three jaggery processing and training centres.

Winter School organized

A 21-days Winter School, "Improving Physiological efficiency for quality cane vis a vis managing post-harvest sucrose losses in sugarcane, Nov 08-28, 2016 sponsored by Education Division of ICAR, New Delhi was organized at ICAR-IISR, Lucknow. Dr. Amaresh Chandra, Principal Scientist, Division of Plant Physiology and Biochemistry was the Course Director.

Other training organized

One and half year ITI apprenticeship training was conducted in the Division of Agricultural Engineering for 9 trainees in different trades namely fitter, welder, electrician, refrigeration and air conditioning.

One month summer training was conducted in the Division of Agricultural Engineering for 13 students of B.Tech. (Ag. Engg.) from SHIATS, Allahabad and MCAET, Ambedkar Nagar during June-July, 2016.

Capacity building of IISR Staff

Sl. No	Name	Name of training programme	Venue	Date
Scientists				
1.	Dr. A.D. Pathak	Executive Development Programme	ICAR-NAARM, Hyderabad	February 17-22, 2017
2.	Dr. M. Swapna	*De novo* Transcriptome Data Analysis	ICAR-CIMAP, Lucknow	June 23-24, 2017
3.	Dr. Arun Baitha & Dr. Deeksha Joshi	Advance application in Nanotechnology	ICAR-CIRCOT, Mumbai	February 6-10, 2017
4.	Dr. Sangeeta Srivastava	18th Indo –US Workshop on Flow Cytometry in Plant Application	Biotech Park, Lucknow	February 21, 2017
5.	Dr. Sangeeta Srivastava	Competency Enhancement Programme for Effective Implementation of Training Functions by HRD Nodal Officers	ICAR, NAARM, Hyderabad	February 23-25, 2017
6.	Dr. A.D. Pathak and Dr. S.K. Shukla	Managing Technology Value Chains for Directors & Divisional Heads	Administrative Staff College of India, Hyderabad	February 27 - March 3, 2017
7.	Dr. Rajesh Kumar	Linear Mixed model in practice An AS-REML-Oriented Approach	ICAR-CIFE, Mumbai	October 13-15, 2016
8.	Dr. A.K. Mall	ICAR Sponsored Winter School on Biotechnological and Conventional Tools for Biotic and Abiotic Stresses Management in Sugarcane	ICAR-Sugarcane Breeding Institute, Coimbatore.	December 7-27, 2016
9.	All Scientists of the Institute	Workshop on Intellectual Property Management	ICAR-IISR, Lucknow	March 30, 2017
Technical				
10.	Drs. M.R.Verma & B.B. Joshi	Competency Enhancement Programme on Soft Skills and Personality Development for Technical Officers of ICAR	ICAR-NAARM, Hyderabad	June 1-10, 2016
11.	Mr. Somnath Singh	Agrometerological Data Collection, Analysis and Management	ICAR-CRIDA, Hyderabad	July 25-August 6, 2016
12.	Dr. Om Prakash, Dr. Ram Kishor, Dr. R.K. Singh, Mr. A.K. Singh	Use and Maintenance of Advanced Instruments in Soil and Plant Analysis	ICAR-IISS, Bhopal	August 8-13, 2016
13.	Mr. A.K. Vishwakarma & Mr. S.K. Sharma	Manufacturing of Agricultural Equipments	ICAR-CIAE, Bhopal	August 16-25, 2016

14.	Mr. Brij Kishore & Mr. Dildar Hussain	9th Capacity Building Programme for Technical Personnel	IIPA, New Delhi	September 5-16, 2016
15.	Mr. S.K. Mishra	Food Processing, Packaging and Value Addition of Agricultural and Livestock Produce	ICAR-CIPHET, Ludhiana	July 29-August 12, 2016
16.	Mrs. Hemlata Madhok & Mr. Raghvendra Kumar	Introduction to Bioinformatics	ICAR-IASRI, New Delhi	November 8-21, 2016
17.	Mr. C.P. Singh, Mrs. Asha Gaur, Dr. Ram Kishor, Mr. Devendra Singh, Mrs. Mithilesh Tewari, Mrs. Pramila Lal	ICAR Sponsored Winter School on Improving Physiological Efficiency for Quality Cane vis-a-vis Managing Post-Harvest Sucrose Losses in Sugarcane	ICAR-IISR, Lucknow	November 8-28, 2017
18.	Mrs. Pallavi	Natinal Training on Integrated Nutrient and Weed Management in Sugarcane	ICAR-IISR, Lucknow	January 19-20, 2017
19.	Mr. A.K. Sachan	47th Short Course on " Advances in Rumen Manipulation to Improve Livestock Productivity'	ICAR-IVRI, Izatnagar, Bareilly	February 1-21, 2017
20.	Mr. Kalp Nath	Automobile maintenance, road safety and behaviourial skills	ICAR-CIAE, Bhopal	February 20-24, 2017
21.	Mr. C.P. Singh, Mr. A.K. Vishwakarma & Mr. S.K. Sharma	10th Capacity Building Programme for Technical Personnel	IIPA, New Delhi	February 20 – March 3, 2017
22.	Mr. I.P. Maurya	National Training on Integrated Pests and Disease Management in Sugarcane	ICAR-IISR, Lucknow	February 27-28, 2017
23.	All Technical Officers	Workshop on Intellectual Property Management	ICAR-IISR, Lucknow	March 30, 2017
Administration				
1	Mr. S.K. Bagchi & Mr. Nag Chand	E Procurement	New Delhi	July 21-22, 2016

CHAPTER 14

Awards and Recognitions

- ICAR-IISR Lucknow has received Research Leadership Award during 9th Global Agriculture Leadership Summit -2016 at Hotel Taj Palace, New Delhi on September 8, 2016. Hon'ble Governor of Uttar Pradesh, Shri Ram Naik Ji gave away the Award to Dr. A.D. Pathak, Director of the Institute in the presence of Hon'ble Governor of Haryana; Prof. K.S. Solanki, Deputy Chairman of Rajya Sabha; Prof. P.J. Kurien, Chairman and Director General of Indian Council of Food and Agriculture and other dignitaries from India and abroad.

- Dr. A.D. Pathak, Director, ICAR-IISR has also received Dr. M.S. Swaminathan Award for outstanding performance in enhancing agriculture production. The award was presented by Shri Ram Naik Ji, Hon'ble Governor of Uttar Pradesh in the Inaugural function of one day Seminar entitled "Improving productivity and quality of hybrid rice and sugarcane in Uttar Pradesh" held at ICAR-IISR, Lucknow on December 18, 2016.

- Dr. Sangeeta Srivastava was conferred NABS-Best Woman Scientist Award-2015 and Fellowship of National Academy of Biological Sciences, at NABS-AGM held at MKU, Madurai on August 08, 2016.
- Dr. J. Singh was conferred *Krishak Mitra Samman* from Nand Educational Foundation for Rural Development (NEFORD) during *Rabi Mela* held at Mau.
- Dr. A.K. Mall was conferred "Young Scientist Award" by Research Wing for Excellence in Professional Education & Industry at Mumbai on September 18, 2016.
- Dr. A.K. Mall was conferred "Pearl Foundation Best Young Scientist Award" for the year 2016 in National Conference entitled "Smart Summit - 2016" by Pearl Foundation Educational Excellence on December 10, 2016.
- Dr. A.K. Mall was conferred "Mahima Young Scientist Award-2016" in International Conference on Medicinal Plants and Management of Lifestyle Diseases held at BHU, Varanasi by Mahima Research Foundation and Social Welfare on December 18, 2016.
- Dr. A.K. Mall was conferred "Excellence in Research Award" for outstanding contribution in field of Agriculture in International Seminar on Agriculture & Food for Inclusive Growth and Development at CSIR-NBRI, Lucknow by *Samagra Vikas* Welfare Society on January 14-15, 2017.
- Dr. S.K. Holkar received Young Scientist Award of the year 2016 for outstanding contribution in field of Plant Pathology on the occasion of International Seminar on Recent Trends and Experimental Approaches in Science, Technology and Nature held at ICAR-IISR, Lucknow on December 23-24, 2016.
- Dr. A.K. Sah received ISEE Fellow Award from Indian Society of Extension Education, New Delhi in ISEE National Seminar at Gwalior on November 28-30, 2016.

- Drs. S.K. Shukla, S.K. Awasthi and, Asha Gaur bagged Outstanding Research Paper Award on "Carbon sequestration for sustaining soil health and improving crop productivity in sugarcane – based system" in "Annual Convention and Technical Expo- 2016", organized by NISSTA at ICAR-IISR, Lucknow on April 29-30, 2016.
- Drs. A.K. Singh, R.Gupta, Sukhbir Singh and R.D. Singh received best paper award for the oral paper entitled "Mechanization of sugarcane for sustainable sugarcane production" presented in National Symposium on Challenges, Opportunities and Innovative Approaches in Sugarcane: Agriculture, Bio-energy and Climate Change held at UPCSR, Shahjahanpur on December 21-23, 2016.
- Drs. Rajesh Kumar, A.D. Pathak and L.S. Gangwar received Second Best Oral Presentation Award in Centennial Fiesta- National Symposium on "Challenges, Opportunities and Innovative Approaches in Sugarcane: Agriculture, Bioenergy and Climate Change held at UPCSR, Shahjahanpur (U.P.) on December 21-23, 2016.

- Drs. C. Gupta and A.K. Sah received Second Best Paper Award in Annual Convention of NISSTA held at ICAR-IISR, Lucknow on April 29-30, 2017.
- Dr. S.K. Holkar received Best Paper Award "Testing and Certification of Tissue Culture Raised Quality Planting Materials at Accredited Test Laboratory, IISR, Lucknow" in the Centennial Fiesta- National Symposium on Challenges, Opportunities and Innovative Approaches in Sugarcane: Agriculture, Bio-energy and Climate Change organised by UPCSR, Shahjahanpur on December 21-23, 2016.
- Drs. R.P. Singh, G.S. Sanghera, V. Tyagi, Rajesh Kumar, K.S.Thind and B. Kumar was awarded Third Best Poster Presentation in Centennial Fiesta- National Symposium on "Challenges, Opportunities and Innovative Approaches in Sugarcane: Agriculture, Bio energy and Climate Change held at UPCSR, Shahjahanpur, (U.P.) on December 21-23, 2016.
- Drs. S. Kumar, P.K. Singh and J. Singh was awarded Best Poster Award for paper "New vistas for utilizing *Saccharum* complex through distant hybridization for diversification of sugarcane agriculture as well as industry" in the First International Agrobiodiversity Congress held at New Delhi on November 6-9, 2016.
- Drs. S.K. Holkar, Harshita Gupta, Atul Kumar, Arun Baitha, Sanjeev Kumar and J. Singh was awarded Best Poster Paper Award in National Symposium on Eco-friendly Approaches for Plant Diseases Management: Recent Trend and Opportunities held at ICAR-IIPR, Kanpur during December 29-30, 2016.
- Drs. Deeksha Joshi, S.K. Holkar, Jaya Gupta, Pushpa Singh, M.R. Singh and Sanjeev Kumar bagged Best Poster Presentation Award in the International Congress on Post-harvest Technologies of Agricultural Produce for Sustainable Food and Nutritional Security held at Integral Institute of Agricultural Science, Lucknow during November 10-12, 2016.
- Drs. Deeksha Joshi, Jaya Gupta, Ayushi and S.K. Holkar bagged Best Poster Presentation Award in the National Symposium on Eco-friendly Approaches for Plant Disease Management held at ICAR-IIPR, Kanpur during December 29-30, 2016.
- ICAR-IISR received First Prize (*Sarvottam Puraskar*) for ICAR-IISR Exhibition stall in *Unnati Krishi Mela* of Ministry of Agriculture and Farmers' Welfare, Govt. of India organized at ICAR-IARI, Pusa, New Delhi during March 15-17, 2017.
- Dr. A.K. Sah received Excellence in Conference Management Award from NISSTA for organising Annual Convention and Technical Expo-2016 held at ICAR-IISR, Lucknow on April 29-30, 2016.
- Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow presided as Chairman of one of the Sessions of International Conference & Exhibition on Sugarcane Value Chain-Vision 2025 Sugar held at Vasantdada Sugar Institue, Pune on November 13-16, 2016.
- Dr. Rajesh Kumar, Principal Scientist presided as Chairman Technical Session V: Transfer of Technologies in Centennial Fiesta- National Symposium on "Challenges, Opportunities and Innovative Approaches in Sugarcane: Agriculture,

Bio-energy and Climate Change held at UPCSR, Shahjahanpur, (U.P.) on December 21-23, 2016.

- Dr. A.K. Singh acted as Chairman of the Technical Session II on Sustainable Sugarcane Production Initiative during National Symposium on Challenges, Opportunities and Innovative Approaches in Sugarcane agriculture, Bio energy and Climate Change held at UPCSR, Shahjahanpur on December 21-23, 2016.
- Dr. Sangeeta Srivastava Co-Chaired the plenary session and valedictory function of National Symposium on Challenges, Opportunities and Innovative Approaches in Sugarcane held at UPCSR, Shahjahanpur on December 21-23, 2016.
- Dr. Sangeeta Srivastava Co-Chaired a session in International Symposium on Plant Biotechnology for Crop Improvement (ISPBCI) held at IIT, Guwahati, Assam on January 21, 2017.
- Dr. Rajesh Kumar, acted as Co-Chairman of the Technical Session II: Sustainable Sugarcane Production Initiative In Centennial Fiesta-National Symposium on "Challenges, Opportunities and Innovative Approaches in Sugarcane: Agriculture, Bio-energy and Climate Change held at UPCSR, Shahjahanpur, (U.P.) on December 21-23, 2016.
- Dr. R.D. Singh acted as Co- Chairman, "Farm Machinery and Power" session during 51st ISAE Convention held at CCSHAU, Hisar on February 16-18, 2017.
- Dr. S.I. Anwar acted as Rapporteur for the Technical Session VII of International Congress on Post-harvest Technologies of Agricultural Produce for Sustainable Food and Nutritional Security held at Integral University, Lucknow on November 10-12, 2016.
- Dr. S.I. Anwar Acted as Rapporteur for the Energy section in 51st Annual Convention and Symposium of ISAE held at CCSHAU, Hisar on February 16-18, 2017.
- Dr. Sukhbir Singh acted as Rapporteur in Session-II, Industry, Government and Academic Institution held on February 16, 2017 in 51st Annual Convention of Indian Society of Agricultural Engineers and National Symposium on the theme Agricultural Engineering for Sustainable and Climates Smart Agriculture held at CCSHAU, Hisar on February 16-18, 2017.
- Dr. A.K. Singh served as Member, Board of Studies of Agricultural Engineering of Dr. Abdul Kalam Technical University (formerly UPTU), Lucknow from January 12, 2016.
- Drs A.K. Singh, S.I. Anwar and R.D Singh served as Vice President, Secretary and Treasurer, respectively of Lucknow Chapter of Indian Society of Agricultural Engineers (ISAE).
- Dr S.I. Anwar is serving as Member, Project Monitoring Committee of Ministry of Environment, Forest and Climate Change, Govt. of India.
- Dr. Sangeeta Srivastava served as Member, Editorial Board of Sugar Tech Journal (Springer), Indian Journal of Fundamental and Applied Life Sciences (Online journal), and Journal of Environmental Biology.
- Dr. A.K. Singh served as Member of Editorial Board of Indian Journal of Sugarcane Technology.
- Dr. M. Swapna served as Editor, Sugar Tech Journal.
- Dr. S.N. Singh served as Editors of Annals of Plant and Soil Research, Current Advances in Agricultural Sciences, *Kisan Jyoti, Ikshu* and *Bhartiya Krishi Anusandhan Patrika.*
- Drs. P.K. Singh and DK Pandey were honoured on the occasion of National Science Day and National Symposium on India Striving Towards One Step Ahead in Science & Technology by U.P. State Bio-energy Board, *Bharat Raksha Dal* Trust, SR Institute of Management & Technology, Lucknow and Association of Chemistry Teachers on February 28, 2017.

CHAPTER 15

Publications

I. Institute Publications

A. Research Papers Published

Anwar SI. 2017. Development of modified jaggery moulding frame for cubical shape jaggery. *Agricultural Engineering Today* 41(1): 44-47.

Baitha A and Varma A. 2016. Growth rate attributes of wild strain of *Trichogramma chilonis* Ishii (Hymenoptera: Trichogrammatidae) reared from sugarcane top borer. *Hexapoda (Insecta indica)* 22(1 & 2):13-17.

Baitha A, Varma A, Singh MR and Maurya BL. 2016. Sex ratios of gregarious *vs.* solitary parasitoid on egg of sugarcane internode borer, *Chilo sacchariphagus indicus* (Kapur). *Hexapoda (Insecta indica)* 22(1 & 2): 69-74.

Chandra P and Chandra A. 2016. Isolation and characterization of plant growth promoting bacteria from wheat-sugarcane cropping system. Journal of Wheat Research 8: 62-65

Choudhary RL, Wakchaure GC, Minhas PS and Singh AK. 2017. Response of ratoon sugarcane to stubble shaving, off-barring, root pruning and band placement of basal fertilizers with a multipurpose drill machine. *Sugar Tech.* 19(1): 33-40.

Gangwar LS, Hasan S Sand Verma MR. 2016. Economic analysis of innovative sugarcane production techniques for realizing food and nutritional security in subtropical India. *Agricultural Economics Research Review* 29 (Conf.): 210.

Ghosh PK, Hazra KK, Venkatesh MS, Singh KK, Kumar N and Mathur RS. 2016. Potential of crop residue and fertilizer on enrichment of carbon pools in upland soils of subtropical India. *Agricultural Research* 5 (3) : 261-268.

Gupta R, Singh PR and Singh AK. 2017. Development of sugarcane-cum-potato planter for mechanization of simultaneous planting of sugarcane and potato. *Sugar Tech.* doi: 10.1007/s12355-016-0504-4.

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Jain R, Singh SP, Singh A, Singh S, Tripathi P, Ram Kishor, Gaur A, Jain N, Shukla SK, Chandra A and Solomon S. 2016. Changes in growth, yield, juice quality and biochemical attributes of sugarcane in response to orthosilicic acid granules. *Sugar Tech* DOI 10.1007/s12355-016-0469-3.

Joshi D, Singh P, Singh AK, Lal RJ and Tripathi N. 2016. Antifungal potential of metabolites from *Trichoderma* sp. against *Colletotrichum falcatum* Went causing red rot of sugarcane. *Sugar Tech.* 18(5): 529-536.

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Kumar A, Baitha A, Pandey RK, Bareliya, PK and Kumar A. 2016. Effect of female *vs.* male pupa of *Scirpophaga excerptalis* Walker on reproductive potential of *Tetrastichus howardi* (Olliff) (Hymenoptera: Eulophidae). *Agrica* 5:1-5.

Kumar D and Singh P. 2016. Effect of some Indian herbs and chemical on shelf life of sugarcane juice. *The Asian J. Hort.* 11(1): 189-193.

Kumar M, Mishra VK, Pathak AD and Mall AK. 2016. Integrated management scenario of *Pyrilla perpusilla* (Walker) in sugarcane crop. *Ecology, Environment and Conservation* 23: 19-23.

Kumar R, Bajpai PK and Pathak AD. 2016. Comparison of modified joint regression analysis, FITCON analysis, EM-AMMI and proposed improved-IMAMMI under incomplete genotype and environment interaction data of sugarcane. *Int. J. Agricul. Stat. Sci.* 12 (1): 210-216.

Kumar R. 2016. Simultaneous selection of high sugar yielding and stable genotypes of sugarcane in India. *Sankhya Vignan* (NSV) 13:17-28.

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Sharma AK and Brahm Prakash. 2016. Business potential and entrepreneurship development in jaggery manufacturing and marketing in India *Indian Journal of Agricultural Economics* 71 (3): 323-324.

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Shrivastava AK and Srivastava S. 2016. Diversity of the germplasm of *Saccharum* species and related genera available for use in directed breeding programmes for sugarcane improvement. *Curr. Sci.* 111 (3): 475-482.

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Singh AK, Sharma MP and Gupta R. 2016. Development of tractor operated double bottom pit digger for mechanizing ring pit method of sugarcane planting. *Sugar Tech.* doi: 10.1007/s12355-016-0488-0.

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CHAPTER 16

Technical Programme 2016-17

Code	Project Title
1. 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 to LT)
B 2.3	Development of sugarcane breeding stocks for high sugar (Raman Kapur and S.K. Duttamajumder, Duration: 4/93-3/16)
B 2.9	Development of top borer tolerant genetic stocks of sugarcane (A.D. Pathak, R.K. Rai, Sangeeta Srivastava, M.R. Singh and Rajesh Kumar; 3/2k-2/18)
B. 2.13	Development of sugarcane varieties for sub-tropics (J. Singh, D.K. Pandey, Sanjeev Kumar, R.K. Singh (Biotech.) 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, Raman Kapur, S.K. Duttamajumder, Arun Baitha and A.K. Mall; 09/08- LT)
B 2.16/Bm 2.1	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; Duration: 06/10-05/18)
B 3.18	Identification and expression analysis of resistance gene analogues against red rot disease in sugarcane (Sangeeta Srivastava, 01/10–03/18)
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 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; Duration: 02/09 to LT)
B 1.2	Evaluation of mid-late sugarcane clones of North West Zone (J. Singh and D.K. Pandey; Duration: 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; Duration: 02/09 to LT)
Externally funded projects	
DBT	RNA seq for SNP mining and linkage mapping in sugarcane (Nandita Banerji and Sanjeev Kumar (Biotech), Duration: 09/14-09/17, Budget ₹ 45.85 lakh)
DBT	National Certification System for Tissue Culture Raised Plants (Sanjeev Kumar (Biotech.) and S.K. Holkar, Duration: 03/15-03/18, Budget ₹ 65 lakh)

PPV&FRA	Central Sector Scheme for PPV&FRA (J. Singh and P.K. Singh (2006 – LT)
Bihar Govt	Breeder Seed Production in Bihar (A.D. Pathak and A.K. Mall)
ICAR Network project	
ICAR	Network project on Transgenics in crops (NPTC) Sub project ICAR-NPTC-3087 (Sanjeev Kumar (Biotech), Crop : Sugarcane) Budget ₹ 98.49 lakh (2015-17)
ICAR	ICAR seed project "Seed production in agricultural crops" (Sanjeev Kumar and P.K. Singh, 2012-17)
Division of Crop Production	
A 2.36	Assessing nutrient interactions for sustaining sugarcane productivity and soil health (R.R. Verma, Ishwar Singh and R.K. Rai; 02/13-03/17)
A 2.37	Sugarcane productivity in relation to initial soil organic carbon content and nutrient management in sub-tropical Inceptisol (T.K. Srivastava, S.R. Singh, Pushpa Singh, K.P. Singh and R.R. Verma; 03/15-03/18)
A 2.38	Soil quality assessment under different sugarcane growing systems (S.R. Singh, T.K. Srivastava, Ishwar Singh, R.R.Verma, Pushpa Singh, S.N. Singh, A.K. Singh (Agron.) and R.S. Dohare; 03/15-03/18)
A 4.10	Developing sugarcane based integrated farming system models for small farm holders of sub-tropical India (A.K. Singh, T.K. Srivastava, R.K. Singh, A.K.Sharma, A.K. Singh (PP), A.K. Singh (Eng), S.P. Singh and M.M. Roy; 09/15-09/18)
AET 1.1	Modulating application of sugarcane production technologies for harnessing production and productivity potential in farmers' field perspective (R.S. Dohare, T.K. Srivastava, Rajesh Kumar, Ishwar Singh, S.N. Singh and M.R. Singh, 04/15–3/20)
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 1.13	Assessment of sugarcane cultivation machines (RMD and RBS-cum planter) on farmer's field (A.K. Sah, A.K. Singh (Engg.) and R.K. Singh; 09/12-09/16)
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)
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 R. Gupta; 09/17-08/22)
A 1.1.33	Studies on biology, interference and management of *Ipomoea* spp. in sugarcane (V.P. Singh, K.K. Singh, S.P. Singh and V.P. Jaiswal; 04/17–03/22)
A 1.2.32	Validation of cane node technology under farmers' field condition (S.N. Singh, A.K. Sah and C. Gupta; 02/16-02/19)
Externally funded projects	
UPCAR	Evaluation of microbial mapping and their correlation on productivity, plant and soil health in maor cropping sytems of Uttar Pradesh (S.R. Singh, Duration 2014-17, Budget ₹ 17.963 lakh)

AICRP on Sugarcane trials	
AS 68	Impact of integrated applications of organics and inorganics in improving soil health and sugarcane productivity (A.K. Singh, K.P. Singh, T.K. Srivastava, S.R. Singh)
AS 69	Use of plant growth regulators (PGRs) for enhanced yield and quality of sugarcane (R.R. Verma and S.R. Singh)
AS 70	Scheduling irrigation with mulch under different sugarcane planting methods (C. Gupta, V.K. Singh and V.P. Jaiswal)
AS 71	Carbon sequestration assessment in sugarcane based cropping system (V.P. Jaiswal, V.P. Singh and S.K. Shukla)
AS 72 (a)	Agronomic performance of elite sugarcane gentoypes (Early) (V.P. Singh and S.K. Shukla)
AS 72 (b)	Agronomic performance of elite sugarcane gentoypes (Mid-late) (K.K. Singh and V.P. Singh)
Contract Research Projects	
Narmada Bio-Chem Limited	Assessing efficiency of PROM (Phosphorus rich organic manure) as an organic source of P on the productivity of wheat-green gram-rice cropping system (S.N. Singh, A.D. Pathak, V.K. Singh, R.K. Singh and Y.P. Singh; 03/17 – 03/19, Budget : ₹ 10.00 lakh)
Sumitomo Chemical India Pvt. Ltd., New Delhi	Field bioefficacy and phytotoxicity evaluation of Flumioxazin 50% SC against weeds in sugarcane and its effect on succeeding crop (V.P. Singh, K.K. Singh, V.P. Jaiswal and S.K. Shukla; 10/16 – 08/19, Budget : ₹ 10.0 lakh)
Bayer	Assessing bioefficacy of Imidacloprid 40% + Fipronil 40% 80 WG against white grub, termite and shoot borer and its impact on cane yield and sugar recovery (S.N. Singh and M.R. Singh, 2014-17, ₹ 7.0 lakh)
Bayer Crop Science Ltd., Mumbai	Bio-efficacy evaluation of tembotrione 420 SC (laudis 420 SC) in sugarcane sugarcane (V.P. Singh, K.K. Singh, A.K. Singh and S.K. Shukla; 02/16-01/18)
Atul Limited, Valsad	Bio-efficacy and phytotoxicity evaluation of RJKP 1505 (2, 4 – D Sodium Salt 67.7% + Metribuzin 16.5 % WG) in sugarcane (V.P. Singh, K.K. Singh, A.K. Singh and S.K. Shukla; 03/16-08/18)
Meghmani Organics Ltd., Ahmedabad	Field bioefficacy and phytotoxicity evaluation of Atrazin 50% WP against weed complex in sugarcane (K.K. Singh, V.P. Singh and S.K. Shukla; 10/16 – 07/17)
Meghmani Organics Ltd., Ahmedabad	Field bioefficacy and phytotoxicity evaluation of Ametryn 80% WG against weed complex in sugarcane (K.K. Singh, V.P. Singh and V.P. Jaiswal; 10/16 – 07/18)
SDS Remedies Pvt. Ltd. Chennai	Bioefficacy and phytotoxicity of Atrazine (50% W) against weeds in sugarcane and its effect on soil health and succeeding crops (V.P. Singh, V.K. Singh, S.K. Shukla and T.K. Srivastava; 08/16-07/17)
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 Division of Crop Protection; 4/06-LT)
Plant Pathology	
M 15.6	Enhancing efficacy of *Trichoderma* based red rot management system (Deeksha Joshi, A.K. Singh and Pushpa Singh; 04/12—03/17)
M 15.7	Mass multiplication of *Trichoderma* on cheaper substrates and development of suitable delivery system for disease management in sugarcane (A.K. Singh and Deeksha Joshi; 04/12-03/17)
M 17	Evaluation/screening of sugarcane germplasm/genotypes against red rot and smut (M.R. Singh, Dinesh Singh and S.K. Duttamajumder); 1992-93 to LT)

M 5.9	Genetic diversity and transmission of pathogens causing Yellow Leaf Disease in sugarcane (S.K. Holkar, Arun Baitha and Sanjeev Kumar (Biotech.); 03/15-03/20)
M 5.10	Management of yellow leaf disease (YLD) of sugarcane through thermotherapy (Dinesh Singh and S.K. Holkar, 05/15-04/18)
Ento 15.1	Containment of major insect-pests of sugarcane through habitat modifications (Arun Baitha and M.R. Singh; 4/12-3/17)
Ento 15.2	Semiochemicals for the management of sugarcane top borer (M.R. Singh and Arun Baitha; 3/12-2/17)
Ento 2.1	Mechanism of resistance against top borer of sugarcane (M.R. Singh, A.D. Pathak, A. Chandra and S.N. Sushil; 4/12-3/17)
Ento 11.2	Development of techniques of mass multiplication of larval parasitoids for management of sugarcane top borer (Arun Baitha and M.R. Singh; 04/12-03/17)
AICRP on Sugarcane trials	
Plant Pathology	
PP 14	Identification of pathotypes in red rot pathogen (M.R. Singh, Dinesh Singh, S.K. Duttamajumder and Lalan Sharma)
PP 17	Evaluation of zonal varieties against red rot, smut and wilt (M.R. Singh, Dinesh Singh, S.K. Duttamajumder and Lalan Sharma)
PP 22	Survey of sugarcane diseases naturally occurring in the area on important varieties (M.R. Singh, Dinesh Singh, S.K. Duttamajumder and Lalan Sharma)
PP 33	Management of yellow leaf disease through meristem culture (S.K. Holkar)
Entomology	
E 4.1 (AICRP)	Evaluation of varieties/genotypes for their reaction against major insect pests (M.R. Singh, A. Baitha and S.N. Sushil)
E. 30 (AICRP)	Monitoring of insect pests and bio-agents in sugarcane agro-ecosystem (M.R. Singh, A. Baitha and S.N. Sushil)
E. 34 (AICRP)	Standardization of simple and cost effective techniques for mass multiplication of sugarcane bio-agents (M.R. Singh, A. Baitha and S.N. Sushil)
Externally funded projects	
ICAR	Studies on rhizospheric microbial diversity in relation to different sugar profile varieties for growth promotion and disease management (Dinesh Singh and R.S. Singh)
Contract research projects	
Bayer Crop Science Limited, Powai, Mumbai (MS)	Evaluation of bio-efficacy of Solomon 300 OD (Beta cyfluthrin 90 + Imidacloprid 210 OD against black bug and cane borers of sugarcane and its effect on natural enemies and sugarcane crop (M.R. Singh and Arun Baitha, 04/16-03/18). Budget: ₹ 7.5 Lakh
4. Division of Plant Physiology and Biochemistry	
PB 23	Optimization of plant population for improving physiological efficiency of sugarcane (R.K. Rai, Pushpa Singh, A. Chandra, Radha Jain and A.K. Shrivastava; 2/10-03/17).
PB 24	Modulating the expression of sucrose metabolizing enzymes for high sucrose accumulation in sugarcane (Radha Jain and A. Chandra; 10/09-3/17)
PB 27	Molecular study to reveal transcriptomes and genes associated with sucrose (GAS) transport and accumulation in sugar (A. Chandra and Radha Jain; 04/12-03/17)
PB 28	Minimizing post-harvest sucrose deterioration and its molecular assessment in sugarcane (A. Chandra and Radha Jain; 04/12-03/17)

PB-Inter-institutional	Screening and identification of sugarcane lines tolerant to water-logging and their physio-biochemical investigation (Radha Jain, A. Chandra, A.D. Pathak, M. Swapna, Vinay Kumar (UPCSR), R. Ramadurai (Shakti Sugar); 03/13-3/18)
Externally funded project	
DST	Functional genomic analysis of differential accumulation of sucrose targeting genes of invertase, sucrose synthase and sucrose phosphate synthase and their impact on source-sink relationships in sugarcane : A. Chandra and R. Jain, Duration 2013 – 16 (SERB/SR/SO/PS/36/2012)
DST-Women Scientist Project	Down regulation of soluble acid invertase SAI gene to minimize post-harvest sucrose loss through RNAi technology in sugarcane (*Saccharum sps. hybrid)* (A. Sharma and A. Chandra) (SRI/WOOS-A/LS 308/2013)
CST, UP	Enhancing sugarcane bioproductivity: physiological and metabolic interventions using nutrient-hormonal carriers (Radha Jain, Amresh Chandra and S.P. Singh, Budget ₹ 11.0 Lakh, Duration 2015-18)
Contract research project	
Cytozyme Labs, Gurgaon	Effect of Cytozyme (USA) products on growth, yield and quality of sugarcane (A.K. Shrivastava, Pushpa Singh, S.K. Shukla, C.P. Prajapati., Duration 2015-17, Budget: ₹ 10 Lakh)
5. Division of Agricultural Engineering	
AE 6.8	Sustaining sugarcane yield under multiple rationing through drip irrigation (Rajendra Gupta ; 03/16 -03/19)
AE 9.1	Design refinement of sugarcane-cum-potato planter (Rajendra Gupta and A.K. Singh; 7/12 – 3/17)
AE 1.22 E	Development of modified furrower type sugarcane cutter planter (A.K. Singh and R.D. Singh, 03/15 – 03/18)
AE 1.52	Development and evaluation of a tractor operated multi-purpose tool frame with attachments for sugarcane cultivation (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 saving attachments (A.K. Singh and Sukhbir Singh; 9/16- 8/19)
AE 7.6.1	Development of integrated drying system for jagerry drying (R.D. Singh, A.K. Singh, S.I. Anwar and Dilip Kumar; 11/16 – 10/18)
AE 1.23	Development of cane node planter (A.K. Singh; 09/16 to 08/19)
AE 7.6.2	Development of a jaggery furnace with efficiency boosting device (S.I. Anwar : 4/12- 3/17)
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/2015/01	Frontline demonstrations of IISR tractor operated ratoon management device (RMD) (A.K. Singh, Sukhbir Singh and A.K. Sah; 01/15-03/18)
FIM/IISR/FLD/2015/3	Frontline demonstrations of IISR tractor operated trench planter (A.K. Singh, Sukhbir Singh and Rajendra Gupta; 02/15-03/18)
FIM/IISR/FLD/2015/4	Frontline demonstrations of IISR tractor operated sugarcane cutter planter (A.K. Singh, Sukhbir Singh and R.D. Singh; 03/15-03/18)
AICRP on Sugarcane trials	
AS 67	Optimization of fertigation schedule for sugarcane through micro-irrigation technique under different agro-climatic conditions (Rajendra Gupta, S.K. Shukla and C.Gupta; 03/12- 03/18)
AICRP on Post Harvest Technology	
LKO/PHTS/14/02	Development of a semi-automatic jaggery manufacturing plant (Dilip Kumar, S.I.Anwar, G.S Nevkar and P.V.K.J. Rao)
LKO/PHTS/16/01	Development of sugarcane juice extractor for households use (Dilip Kumar and S.I. Anwar)
LKO/PHTS/16/02	Development of jaggery gems using liquid nitrogen (Dilip Kumar and S.I. Anwar)
LKO/PHT/14/01	Value addition of jaggery with Indian spices and herbs for increased market value (S.I. Anwar and Dilip Kumar)
Externally funded projects	
ICAR	Agri-consortia research platform on water (Rajendra Gupta, T.K. Srivastava, R.K. Rai, J. Singh, Pushpa Singh, S.R. Singh, R.R. Verma and S.N. Singh; 12/15- 03/18)
Project No. LKO/PHTS/13/2	Study on determining on storage losses in food grains in FCI and CWC warehouses and to recommend norms for storage loses in efficient warehouses (ICAR-FCI Project, Dilip Kumar and S.I. Anwar, Duration : 01/13-12/16)
6. Agrometeorology Unit	
Externally funded project	
ICAR Network: ICAR/NICRA Project	Assessment of impact of climate change on productivity and quality of sugarcane and opportunities of adaptation under sponsored grant component of NICRA (A.K. Shrivastava and T.K. Srivastava; Duration : 04/13-03/17)
7. Agricultural Economics, Statistics and Computer Applications	
AES 4.14	Geographic information system of sugarcane and sugar in India (Rajesh Kumar and S.S. Hasan; 03/12 –03/17)
AES 4.15	Development of data mining and presentation tools in sugarcane (S.S. Hasan, L.S. Gangwar and Rajesh Kumar; 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, A.K. Shrivastava 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, 10/15-09/17)
AES 4.19	Online database and mixed model analysis of sugarcane varieties tested/released in India (Rajesh Kumar, A.D. Pathak and S.S. Hasan, 2017 to 2021)
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)

CHAPTER 17

Review, Monitoring and Evaluation

QRT Meeting

The Meeting of QRT, constituted to review the research work done by ICAR-Indian Institute of Sugarcane Research, Lucknow; AICRP on Sugarcane and *Krishi Vigyan Kendra* for the period of 2010-2015 was held during April 25-27, 2016 under the chairmanship of Dr. J.B. Chaudhary, Ex. Vice Chancellor, G.B. Pant University of Agriculture and Technology, Pantnagar; Dr. N. Vijayan Nair, Ex. Director, SBI, Coimbatore; Dr. D.C. Upreti, Ex. National Fellow, IARI, New Delhi; Dr. Menhi Lal, Ex. Head, Division of Crop Production, ICAR-IISR, Lucknow; Dr. Bacchan Singh, Ex. Professor (Agril. Engineering), GBPUA&T, Pantnagar and Dr. R.K. Samanta, Ex. Director, MANAGE and ICAR-NAARM, Hyderabad were the other members of QRT who were present in the meeting. The meeting was attended by all the scientists of the Institute along with Dr. A.D. Pathak, Director and Dr. P.K. Singh, Member Secretary. All the Heads of the Divisions, PC, AICRP on Sugarcane and Sectional In charges made the presentation of their achievements before QRT. The QRT team also visited laboratories and field trials. The recommendations of the Committee was approved by the Council in its 238th Meeting of the Governing Body held on October 18, 2016.

RAC Meeting

XXII Meeting of RAC of ICAR-IISR was held under the Chairmanship of Dr. A.N. Mukhopadhaya, Ex- Vice Chancellor, AAU, Jorhat during June 29-30, 2016. Shri Vipin Kumar Dwivedi, Cane Commissioner, Uttar Pradesh; Dr. N. Balasundaram, Ex-Director, ICAR-Sugarcane Breeding Institute, Coimbatore; Dr. D.G. Hapase, Ex-Director, V.S.I., Pune; Dr. A.S. Patil, Ex-Director, V.S.I., Pune; Dr. Surendra Singh, Ex- Project Coordinator, Farm Implement & Machinery; Dr. R.K. Singh, Assistant Director General (Commercial Crops),

ICAR, New Delhi; Shri J.L. Jain, General Manager (Cane), Harinagar Sugar Mills, Harinagar (Bihar); Shri K.P.S. Rathi, Farmers representative from Muzaffarnagar (U.P.) besides Dr. A.D. Pathak, Director; Dr. S.N. Singh, Principal Scientist (Agronomy) as Member Secretary, Project Coordinator (Sugarcane), Heads of Divisions and Scientists from ICAR-IISR were also present. On this occasion, an innovative farmer, Prof. C.S. Tiwari was felicitated by the RAC for his contribution in sugarcane cultivation in Narsinghpur district of Madhya Pradesh. All the Heads of Divisions and Incharges presented their research achievements made during 2015-16. The RAC appreciated the efforts of the scientists of the Institute. RAC made following major recommendations:

- The experimental trials conducted on the application of GA_3 in sugarcane at the Institute farm has shown excellent results. This must be tested at three locations on the farmers' fields/ sugar factory areas of the East, Central and the West zones of U.P., Bihar and Maharashtra for validation of the technology and its assessment in variable agro-climatic conditions.
- The R&D work being done on *Trichoderma* needs to be intensified and its role in bio-priming should be studied. The zinc solubilising capacity of *Trichoderma*, the scope of using it for seed pelletting, its use as a cost-effective technology for sugarcane cultivation etc., are other researchable issues. *Trichoderma* cultures should be supplied to atleast two sugar mill and its impact on the overall sugarcane production should be studied.
- There is an emergent need to follow the standard protocols and techniques with proper identification/characterization of the microbes for quality biofertilizer production and maintenance.

- There is a need to have inter-institutional linkages pertaining to formulation and execution of need-based field trials at different locations besides developing strong coordination with the state cane development departments and sugar industries.
- A database with respect to meteorological parameters, varietal balance, soil nutrients status, cultivation practices etc., for the last 10 years, two each from the eastern, central and western zones of U.P., should be compiled and analyzed, so that a valid and scientific conclusion in this context could be drawn.
- Deep furrow sugarcane planter with herbicide spray attachment and wide-spaced multi-purpose planter should be tested in the tropical belt of India also. List of sugarcane machines developed by the Institute should be sent to the Ministry of Agriculture and Farmers Welfare, Govt. of India with a proposal for seeking subsidy on these implements.
- Pre-breeding activity may be strengthened as a long term project with specific target characters as well as, stable, quantifiable and easily definable traits such as high sugar, disease resistance, ratoon regeneration, canopy characteristics, self detrashing etc., in collaboration with ICAR- SBI, Coimbatore.
- ICAR-IISR should guide at least two sugar mills for establishing laboratories at factory level itself for farmers benefit as a "Bio-Village" Mission.
- Identification of molecular markers for drought tolerance in sugarcane should be taken up, keeping in mind the water deficit situations being faced in sugarcane cultivation.
- Short duration International training programmes on sugarcane production and management is needed to strengthen the relations with other countries and to establish linkages with World Bank/African Development Bank/Asian Development Bank/NABARD/Department of Sugar *etc.*

Group Meeting on "Recasting of Biofertilizers and Biopesticides Production Programme of ICAR-IISR, Lucknow"

A Group Meeting on "Recasting of Bio-fertilizers and Bio-pesticides Programme of ICAR-IISR, Lucknow was held on June 27, 2016 at the Institute under the Chairmanship of Dr. A.N. Mukhopadhaya, Chairman RAC & Ex- Vice Chancellor, AAU, Jorhat. The meeting was attended by Dr. A.D. Pathak, Director, ICAR-IISR; Dr. S.N. Singh, Principal Scientist (Agronomy) and Member-Secretary, RAC, Dr. H.B. Singh, BHU, Varanasi; Dr. Rakesh Pandey, CSIR-CIMAP, Lucknow; Dr. G.P. Rao, ICAR-IARI, New Delhi; Shri H.M. Shukla, Deputy

Manager (Biofertilizers), KRIBHCO, Phulpur, Allahabad *etc.* and scientists from ICAR-IISR. It was recommended that there was an emergent need to follow standard protocols and techniques with proper identification/ characterization of the microbes for quality biofertilizer production and maintenance. It was also suggested to name it as bio-manure since it can be sold as such without licensing, registration etc. The Institute should concentrate on making liquid bio-manure, using cell retardants for longer maintenance of the cultures and reviving the cultures with specific compounds. Thermo-tolerant strains of microbes need to be developed and the same can be tried by spraying on undecomposed press mud from sugar factories before applying to sugarcane fields.

IRC Meeting

The Institute Research Council (IRC) meeting of the Institute (ICAR-IISR), Lucknow was held under the Chairmanship of Dr. A.D. Pathak, during September 21-23, 2016 to review and discuss the on-going research projects. In this meeting, 54 scientists and three technical officers of the Institute participated and discussed the research findings of on-going research projects. The four teem new research projects were approved in principle.

IMC Meetings

Forty first meeting of Institute Management Committee (IMC) was held under the Chairmanship of Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow on April 27, 2016. Forty second meeting of the IMC was held on October 28, 2016. Progress of R & D efforts was reviewed and various administrative matters were discussed in the meeting.

CHAPTER 18

Participation in Seminars/Symposia/Conferences/Workshops/ Meetings

Name	Conference/Seminar/Symposia	Venue	Date
Dr. A.D. Pathak	Conference on Grain Storage and Preventing Post-harvest Losses	New Delhi	April 22, 2016
Drs. L.S Gangwar & S.S Hasan	3rd National Conference on River Basins: Ecosystem Crises and Water Scarcity	IERT, Allahabad	April 23-24, 2016
All Scientists	NISSTA Annual Convention and Technical Expo 2016	ICAR-IISR, Lucknow	April 29-30, 2016
Dr. A.K. Singh	Workshop on Farmer Water School Curriculum Development	Lucknow	May 5-7, 2016
All Scientists	XXIII Annual Zonal Workshop on KVKs of Uttar Pradesh and Uttarakhand	ICAR-IISR, Lucknow	May 26, 2016
Dr. A.K. Sah	*Akhil Bhartiya Rajbhasha Hindi Sammelan Evam Chintan Shivir*	Munnar	June 1-3, 2016
Dr. A.D. Pathak & Dr. P.K. Singh	QRT Meeting	NASC Complex, New Delhi	June 6, 2016
Dr. Sanjeev Kumar	Awareness Programme on National Certification System for Tissue Culture-raised Plants (NCS-TCP)	DBT/BCIL, New Delhi	June 10, 2016
Dr. A.K. Sah	National Conference on Integrated Communication Strategy for Agricultural development	Lucknow	June 14-15, 2016
Dr. A.D. Pathak	237th Meeting of the Governing Body of the ICAR Society	NASC Complex, New Delhi	June 28, 2016
Dr. A.K. Singh	Academia-Industry Interface	ICAR Research Complex for Eastern Region, Patna	June 28, 2016
Dr. P.K. Singh	Workshop on Take it to Breeders & Researchers-the Plant Breeders' and Researchers' Rights through Awareness and Streamlining of Farmers' Varieties Congress	PPV&FRA, New Delhi	June 30, 2016
Dr. Sanjeev Kumar	Stakeholders Meet on National Certification System for Tissue Culture Raised Plants (NCS-TCP)	DBT/BCIL, New Delhi	July 4, 2016
Dr. A.K. Singh	National Conference on Innovations in Agricultural Mechanization	Vigyan Bhawan, New Delhi	July 7-8, 2016
Dr. A.D. Pathak	Inter State Hort. Fair *Sangam*-2016	Hazipur	July 9-10, 2016
Dr. Rajendra Gupta	46th Annual Convention of SISSTA	Chennai	July 15-16, 2016

Dr. A.K. Singh	Tractor, Agricultural Machinery Manufacturer Exhibition and Meet 2016	Coimbatore	July 15-18, 2016
Dr. Rajesh Kumar	Sub-committee on Sugarcane Seed and Approval of Sugarcane Varieties for Cultivation in Uttar Pradesh	*Ganna Kisan Sanshthan*, Lucknow	July 26, 2016
Drs. A.K. Singh, Rajesh Kumar, Rajendra Gupta & A.K. Sah	74th Annual Convention of Sugar Technologists Association of India (STAI)	Delhi	July 28-30, 2016
Dr. Sangeeta Srivastava	9th NABS National Conference on New Biological Researches	MKU, Madurai	August 11-12, 2016
Dr. A.D. Pathak	Plant Genome Saviour Awards Ceremony	New Delhi	August 24, 2016
Drs. A.D. Pathak & Rajesh Kumar	XXIII Meeting of ICAR Regional Committee No. IV	ICAR-RCER, Patna	August 26-27, 2016
Dr. A.K. Sah	*Hindi Sangoshthi*	Gurunanak Dev University, Amritsar	August 26, 2016
Drs. A.D. Pathak & A.K. Sah	9th Global Agriculture Leadership Summit	Hotel Taj Palace, New Delhi	September 8-9, 2016
Dr. Sangeeta Srivastava	Workshop on Bio-Entrepreneurship and Bio-Enterprise Creation	Biotech Park, Lucknow	September 16, 2016
All Scientists	IRC meeting	ICAR-IISR, Lucknow	September 21-23, 2016
Dr. S.I. Anwar	National Conference on Innovative Food Processing Technologies for Food and Nutritional Security	ICAR-CIPHET, Ludhiana	September 29-30, 2016
Dr. Dilip Kumar	Meeting on CSIR Mission Mode Programme on Food Safety: Packaging Solutions	CSIR Science Centre, New Delhi	October 13-14, 2016
Dr. A.D. Pathak	238th Meeting of the Governing Body of the ICAR Society	NASC Complex, New Delhi	October 18, 2016
Dr. A.K. Sharma	30th Annual Conference of the Indian Society of Agricultural Marketing	BHU, Varanasi	October 20-22, 2016
Drs. J. Singh, PK Singh, Sanjeev Kumar & A.K. Mall	1st International Agro-biodiversity	NASC Complex, New Delhi	November 6-9, 2016
Dr. Rajendra Gupta	Meeting to review Project on Agri-Consortia Research Platform on Water	ICAR-IIWM, Bhubaneswar	November 7-8, 2016
Dr. Dilip Kumar	10th International Conference on Controlled Atmosphere and Fumigation in Stored Products	New Delhi	November 7-11, 2016
Drs. Sangeeta Srivastava & S.I. Anwar	International Congress on Post-harvest Technologies of Agricultural Produce for Sustainable Food and Nutritional Security	Integral University, Lucknow	November 10-12, 2016

Drs. A.D. Pathak, S.K. Shukla, Rajesh Kumar, T.K. Srivastava, A.K. Singh, A.K. Sharma, A.K. Sah, Dinesh Singh, V.K. Gupta, A.K. Mall, Chandra Gupta, Rajendra Gupta, L.S. Gangwar, Arun Baitha, V.P. Jaiswal, Lalan Sharma, S.P. Singh, S.K. Awasthi, G.K. Singh & Adil Zubair	International Conference and Exhibition on Sugarcane Value Chain-Vision 2025 Sugar	VSI, Pune	November 13-16, 2016
Mr. Sunil Kumar Mishra	Animal Science Exhibition	KVK, Chaukimafi, Gorakhpur	November 15, 2016
Dr. Arun Baitha	SDF Meeting	New Delhi	November 16, 2016
Drs. A.D. Pathak, S.K. Shukla, M.R. Singh, Rajesh Kumar, T.K. Srivastava, V.P. Singh, S.N. Sushil, A.K. Singh, J. Singh, P.K. Singh, K.K. Singh, Rajendra Gupta, V.K. Gupta, Sanjeev Kumar, S.S. Hasan, R.R. Verma, A.K. Mall, Chandra Gupta, Dinesh Singh, V.P. Jaiswal, Lalan Sharma, S.K. Awasthi, G.K. Singh, Adil Zubair & A.K. Yadav	31st Biennial Workshop of AICRP on Sugarcane	VSI, Pune	November 16-17, 2017
Dr. A.K. Sharma	76th Annual Conference of the Indian Society of Agricultural Economics	AAU, Jorhat	November 21-23, 2016
Drs. S.K. Shukla, T.K. Srivastava, A.K. Singh, S.N. Singh, Chandra Gupta & S.R. Singh	4th International Agronomy Congress on Agronomy for Sustainable Management of Natural Resources, Environment, Energy and Livelihood Security to Achieve Zero Hunger Challenge	New Delhi	November 22-26, 2016
Dr. Dinesh Singh	14th International *Trichoderma* and *Glicladium* Workshop	Nagpur	November 27-29, 2016
Dr. A.K. Sah	ISEE National Seminar on Information and Communication Management concerning Climate Smart Agriculture for Sustainable Development and Poverty Alleviation	RVSKVV, Gwalior	November 28-30, 2016
Dr. S.R.Singh	National Workshop of AICRP on STCR	MPKV, Rahuri	December 2-5, 2016

Dr. A.D. Pathak & all Scientists	National Symposium on Noni and Medicinal Plants for Health and Livelihood Security	ICAR-IISR, Lucknow	December 3-4, 2016
Dr. T.K. Srivastava	5th Annual Workshop on NICRA	NASC Complex, New Delhi	December 9-10, 2016
Drs. A.D. Pathak, Arun Baitha & Sanjeev Kumar	Meeting of Sub-Committee for Grant in aid Sugar Development Fund to research project	Krishi Bhawan, New Delhi	December 14, 2016
Dr. L.S. Gangwar, Atul Kumar Sachan & Mohd. Ashfaque	24th Annual AERA Conference	ICAR-IVRI, Bareilly	December 15-17, 2016
Dr. A.D. Pathak & all Scientists	Seminar on Improving Productivity and Quality of Hybrid Rice and Sugarcane in U.P.	ICAR-IISR, Lucknow	December 18, 2016
Drs. S.N. Singh, Rakesh Kumar Singh & Sunil Kumar Mishra	Foundation Stone Laying Ceremony of *Gur* Processing and Training Unit	KVK, Chaukmafi, Gorakhpur	December 21, 2016
Drs. S.K. Shukla, M.R. Singh, Sangeeta Srivastava, Rajesh Kumar, M. Swapna, D.K. Pandey, A.K. Singh, Akhilesh Kumar Singh, Chandra Gupta, Rajendra Gupta, Kamta Prasad & Brahm Prakash	National Symposium on "Challenges, Opportunities and Innovative Approaches in Sugarcane: Agriculture, Bio –energy and Climate Change"	UPCSR, Shahjahanpur	December 21-23, 2016
Dr. A.K. Singh	Annual Workshop of AICRP on Farm Implements and Machinery	TNAU, Coimbatore	January 3-5, 2017
Dr. Rajesh Kumar	Consultative Meet with the Line Department of UP to discuss the State Credit Potential – 2017-18	NABARD, Lucknow	January 6, 2017
Dr. S.N. Sushil	Meeting of FAD 02	BIS, New Delhi	January 11, 2017
Dr. Sangeeta Srivastava	International Symposium on Plant Biotechnology for Crop Improvement	IIT, Guwahati	January 20-21, 2017
Dr. A.D. Pathak & all Scientists	Zonal Breeders Meet of AICRP (S)	ICAR-IISR, Lucknow	January 23, 2017
Drs. A.D. Pathak & Pushpa Singh	Meeting with Hon'ble Minister, Ministry of Road Transport and Highways, Govt. of India	New Delhi	January 24, 2017
Dr. Y.P. Singh & Sh. Sunil Kumar Mishra	National Farmers' Fair	ICAR-IIVR, Varanasi	January 26-27, 2017
Dr. A.D. Pathak	Consultancy Meeting	Baramati, Pune	January 30-31, 2017
Dr. A.D. Pathak	239th Meeting of the Governing Body of the ICAR Society	NASC Complex, New Delhi	February 1, 2017
Dr. A.D. Pathak & all Scientists	Interface Meeting of Research Institutes, Cane Development and Sugar Mills officials	ICAR-IISR, Lucknow	February 06, 2017

Drs. R.D. Singh & S.I. Anwar	OLARIS 2017- National Conference on Renewable Energy Sources for Sustainable Climate	BHU, Varanasi	February 7-9, 2017
Dr. A.D. Pathak & S.K. Shukla	Director's Conference	New Delhi	February 14-15, 2017
Dr. A.D. Pathak	ICAR Annual General Meeting	Krishi Bhawan, New Delhi	February 16, 2017
Drs. R.D. Singh, S.I. Anwar & Sukhbir Singh	51st Annual Convention and Symposium of Indian Society of Agricultural Engineering	CCSHAU, Hisar	February 16-18, 2017
Dr. Amaresh Chandra	13th Agricultural Science Congress	UAS, Bengaluru	February 21-24, 2017
Dr. J. Singh	11th Review Meeting of PPVFRA	IGKV, Raipur	February 27-28, 2017
Drs. R.D. Singh, S.I. Anwar & Dilip Kumar	4th Lucknow Science Congress	BBAU, Lucknow	March 2-3, 2017
Dr. S.K. Shukla	Coordination Committee Meeting for organizing International Conference - Agri Con 2018	CSAUA&T, Kanpur	March 8, 2017
Drs. A.D. Pathak & Rajesh Kumar	Meeting with Chairman, ASRB for online examination of ASRB	ASRB, New Delhi	March 10, 2017
Dr. A.K. Singh	National Symposium on Sugarcane Mechanisation- Challenges & Opportunities	B.A. Institute of Technology, Coimbatore	March 17-18, 2017
Dr. S.K. Shukla	Meeting of Varietal Identification Committee	Krishi Bhawan, New Delhi	March 20, 2017
Dr. A.D. Pathak	State-wise Coordination Committee Meeting for doubling farmers' income	ICAR-IVRI, Izatnagar	March 20-21, 2017
Dr. V.P. Jaiswal	28th National Workshop on AICRP on Micro & Secondary Nutrients and Pollutant Elements in Soils and Plants	ICAR-IISS, Bhopal	March 21-23, 2017
Dr. S.N. Sushil	Meeting on Improvement/ Harmonization of Guidelines of Registration Committee of Pesticides	Krishi Bhawan, New Delhi	March 23, 2017
Drs. S.K. Shukla, S.N. Singh, L.S. Gangwar & Kamta Prasad	National Conference on Farmers Centric Agri-innovation for Sustainable Development	CSAUA&T, Kanpur	March 25-26, 2017
Dr. Sangeeta Srivastava	Brain Storming Session on Strategies for Breaking Physio-genetic Yield Barriers in Pulses	UPCAR, Lucknow	March 27, 2017
Dr. A.K. Sah	*Varshik Goshthi* of Doordarshan, Lucknow	ICAR-IISR, Lucknow	March 28, 2017
Dr. L.S Gangwar	Brain Storming Session on Marketing Strategies for Vegetables Crops in U.P.	UPCAR, Lucknow	March 29, 2017
All Scientists & Technical Officers	Workshop on Intellectual Property Management	ICAR-IISR, Lucknow	March 30, 2017

CHAPTER 19

Events Organized

Pradhan Mantri Phasal Bima Yojana Awareness Programme

An awareness programme on "*Pradhan Mantri Phasal Bima Yojana*" was organized at ICAR-IISR, Lucknow on April 2, 2016 which was inaugurated by Sri Rajnath Singh Ji, Hon'ble Home Minister, Govt. of India. In his inaugural address, he highlighted various schemes of Govt. of India for the benefits of farmers. While addressing the large gathering of the farmers, scientists and officers from Lucknow, Sitapur, Unnao, Auriya, Hardoi, Raebareli, Minister remarked that 100 districts of the country have been targeted under *PM Agriculture Irrigation scheme* and by the end of 2016, the irrigation plan of these districts will be finalized. Similarly for making the excess flood water available to the dry and drought prone areas, the river linking scheme will be strengthened. Highlighting the special features of *Phasal Bima Yojana*, he told that the farmers will have to pay low premium for insuring their crops which will be 2% for *Kharif* crops, 1.5% for *Rabi* crops and 5% for commercial and horticultural crops. Remaining amount of the premium will be borne by the Government.

Director, ICAR-IISR, Lucknow, Dr. A.D. Pathak welcomed the Chief Guest and in his welcome address, highlighted the significant achievements of the Institute. Dr. S.N. Singh, Principal Scientist, ICAR-IISR, Lucknow proposed vote of thanks to the distinguished guests, invitees and farmers.

IISR Foundation Day

The 66th Foundation Day of ICAR-IISR, Lucknow was celebrated on February 16, 2017 with great fervour and enthusiasm. Speaking on the occasion, Padamshree Dr. M.M. Godbole, Professor, Department of Molecular Medicine & Biotechnology, SGPGI, Lucknow gave a brief presentation on importance of Iodine in the soil, agricultural products and food. He narrated the story of his journey towards identifying iodine deficiency as the root cause of goitre. He informed how he popularize iodized salt to combat fight against goitre. Dr. S.K. Shukla, PC, AICRP on Sugarcane narrated the significant achievements of the Institute. He informed that this year, Uttar Pradesh is likely to emerge as a major sugar producing state of the country.

Chairing the Session, Dr. S. Rajan, Director, ICAR-CISH, Lucknow appreciated the research work done by the Institute during last six and a half decade for the betterment of sugarcane farmers and sugar industry. He also urged the Scientists to learn from the story of Dr. Godbole to devote their arduous efforts to achieve the goal with limited resources. He also offered the cooperation of ICAR-CISH, Lucknow for canning fresh sugarcane juice. More than 500 students and farmers visited the laboratories and research farm of the Institute on this occasion. During their visit, they were acquainted with newly developed IISR technologies pertaining to various disciplines.

National Science Day

National Science Day was celebrated at ICAR-IISR, Lucknow with a great fervour on February 28, 2017. Speaking as the Chief Guest on the occasion, Dr. Narayan Prasad, Professor, Department of Nephrology, SGPGI, Lucknow highlighted importance of applications of technologies in the life of specially abled person for doing wonders in their life. This could be possible with the combined efforts of scientists from different fields like Basic Sciences, Engineering and Medical Sciences. Dr. Prasad urged the technocrats to vow for some new inventions which can be used for the well being of these persons.

Chairing the session, Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow informed about the innovative sugarcane production technologies developed by the Institute for the upliftment of the status of the sugarcane farmers. He also informed that due to the interventions of these technologies this year, Uttar Pradesh has emerged as the largest sugar producing state of the country. He urged the scientists of the Institute to work in unison of other scientific disciplines and try to work more in inter-disciplinary mode for the betterment of the

society. Dr. P.K. Singh, Principal Scientist, Division of Crop Improvement gave an insight of mobile based digital transaction in daily life. He urged all to use cashless mode of transaction by using any mobile based platform including BHIM (Bharat Interface for Money) App, recently launched by the Govt. of India.

World Soil Day

On December 5, 2016, World Soil Day was celebrated at the Institute. Dr. P.N. Singh, was the Chief Guest. Dr. Singh expressed his concern over deteriorating quality of soil, water and food due to ignorance. He said that soil is a critical component of the natural system and is a vital contributor to human well-being. He urged that scientists and extension personnel must work in synchronization to address these challenges.

Dr. A.D. Pathak, welcomed the participants and stressed the importance of soil, water and air for the existence of life. He said that soil is the reservoir for at least a quarter of global biodiversity, and therefore, needs immediate attention. He outlined the progress made by the Institute in various soil related research projects. He also assured that the distribution of Soil Health Card scheme adopted by the Institute will be intensified in the future.

World Students Day

World Students Day was celebrated at ICAR-IISR, Lucknow on October 15, 2016. In 2010, United Nations decided to mark the importance of India's former President and great scientist Dr. APJ Abdul Kalam and declared his birthday as 'World Students Day'. On this occasion, Director addressed the UG/PG students, Ph.D. scholars and research fellows working in various projects in the Institute. During his address, he urged the students to work hard towards their respective aims. He also encouraged them to be more focused and open for the innovative ideas and also added that young people are torchbearer of the future. He also asked the students to communicate him any innovative idea to be persued at.

Parthenium Eradication Awareness Programme

An awareness programme on *Parthenium* eradication was organized at KVK, ICAR-IISR, Lucknow on August 19, 2016. Dr. A.D. Pathak, Director highlighted that *Parthenium* is responsible for health problems in human and animals, besides deteriorating environment, loss of productivity and biodiversity. This weed was first noticed in India during 1955 and has now covered more than 35 million hectare area.

Agriculture Education Day

On 3rd December 2016, ICAR – IISR, Lucknow organized Agricultural Education Day to commemorate the birth anniversary of first President of India, Bharat Ratna, Dr. Rajendra Prasad. On this occasion, Dr. A.D. Pathak, Director established one to one dialogue with all researchers working in different research projects and UG/PG and Ph.D. students pursuing their research work at IISR. He emphasized the importance of agricultural education and its relevance in day to day life and called upon the young researchers to learn more and think "out-of-the-box" to bring change in the system.

23rd Annual Zonal Workshop on KVKs of Uttar Pradesh and Uttarakhand

XXIII Annual Zonal Workshop on KVKs of U.P. and Uttarakhand was inaugurated by Sh. Ram Naik ji, Hon'ble Governor of Uttar Pradesh at ICAR-IISR, Lucknow on May 26, 2016. While addressing the gathering, Sh. Ram Naik ji highlighted that KVK is a grass root level institution with immense potential for strengthening agriculture and related industries for bringing prosperity to the villages which ultimately may culminate to national prosperity. Terming the KVK as lighthouse for the farmers and are capable to offer scientific direction to the farmers, especially in the current changing scenario of Indian agriculture and to play an effective role for disseminating welfare schemes of the farmers started by the Central Govt., he urged the KVK scientists to go to the fields to demonstrate the impact of the improved technologies. Dr. A.K. Singh, DDG (Ag. Extension), ICAR expressed his concern over the vacant positions of KVKs in U.P. and Uttarakhand despite cent per cent financial assistance by the ICAR. He advocated for more autonomy for KVK Heads and more facilities for KVK staff. Dr. A.D. Pathak, Director, ICAR-IISR highlighted the R & D contributions of the Institute for the economic development of sugarcane farmers and the state and proposed the formal vote of thanks to all the delegates and dignitaries.

Meeting of ICAR-IISR, Lucknow and UPCSR, Shahjahanpur with Cane Department of Uttar Pradesh

A meeting of ICAR-IISR, Lucknow and UPCSR, Shahjahanpur and Sugarcane and Sugar Department, Govt. of U.P. was held at ICAR-IISR, Lucknow on August 22, 2016 to discuss various issues pertaining to increasing yield of sugarcane in U.P. Apart from Scientists of IISR, Lucknow and UPCSR, Shahjahanpur, the meeting was attended by Cane Commissioner along with other officers of Sugarcane and Sugar Department, Govt. of U.P.

The Scientists of the Institute informed about the latest developments in the field of crop improvement, crop production, crop protection and agricultural engineering. Dr. V.K. Shukla, Additional Cane Commissioner, Govt. of U.P. advocated for a reduction of area under rejected varieties and maintaining a balance of recommended varieties. The U.P. Government is promoting drip irrigation, organizing village level *Kisan Goshthi*, visit of farmers at the farms of innovative farmers, nursery raising of seed cane, establishment of ideal sugarcane village and *Ganna Kisan Club* in each sugar mill..

Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow told the organization of this coordination meeting as a good initiative for utilizing the strength of each other and felt the need for developing a strong road map of sugarcane for U.P. He advocated for adoption of sugarcane implements and devices, crop protection techniques and tissue culture plants in addition to varietal replacement and healthy seed production using MHAT. Sh. Vipin Kumar Dwivedi, Cane and Sugar Commissioner, Govt. of U.P. expressed satisfaction over emergence of U.P. as the largest sugar producing state of the country. He assured that IISR technologies will be disseminated through out the state through the network of Cane Department. Sh. Dwivedi termed this meeting as a humble beginning and assured that the Cane Department will meet with ICAR-IISR scientists more frequently.

Interactive meeting of Sugarcane R & D and Sugar Mills and Brain-Storming Session

An interactive meeting of Sugarcane R & D and Sugar Mills and Brain-Storming Session was held at ICAR-IISR, Lucknow on February 6, 2017. Dr. S. Solomon, Vice-Chancellor, CSAUA&T, Kanpur was the Chief Guest and the meeting was presided by Sh. Vipin Kumar Dwivedi, Sugarcane Commissioner, U.P. The meeting was attended by the representatives of 118 sugar mills, Senior Officers of Sugarcane & Sugar Development, Scientists of ICAR-IISR, Lucknow and UPCSR, Shahjahanpur. It was decided to constitute a committee under the chairmanship of Dr. Solomon to develop an effective strategy after discussing various aspects of sugarcane seed supply. Dr. A.D. Pathak, Director, ICAR-IISR gave a detailed presentation on improved varietal development of sugarcane and seedcane production. He also urged for the entrepreneurship development.

Foundation Stone Laying Ceremony of *Gur* Processing and Training Unit

The foundation stone laying ceremony of a *gur* processing and training unit was laid by Hon'ble M.P., Yogi Adityanath Ji at Mahayogi Gorakhnath KVK, Gorakhpur on December 21, 2016. The programme was

jointly organized by ICAR-IISR, Lucknow and ICAR-ATARI, Kanpur for doubling the farmers income in next five years and making the farmers self reliant. Dr. A.D. Pathak informed that 70% of sugarcane produced is used for sugar production, while 19% is used for jaggery production. Under the circumstances, when sugar mills are unable to crush the sugarcane, jaggery production is a better alternative for increasing farmers income.

Rabi Kisan Sammelan

Rabi Kisan Sammelan was organized by KVK, Lucknow at ICAR-IISR, Lucknow on January 28, 2017. Inaugurating the programme, the Chief Guest, Dr. S.

Solomon, Vice-Chancellor, CSAUA&T, Kanpur said that KVKs and the farmers are playing an important role for the agricultural development. Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow urged the farmers to reap the benefits of improved farm production technology. He gave a detailed presentation on improved varieties, sugarcane production and protection technologies.

Annual Convention of NISSTA and Technical Expo 2016

Two days Annual Convention of NISSTA and Technical Expo 2016 was organized at ICAR-IISR Lucknow on April 29-30, 2016. Sh. Pravir Kumar,

Agricultural Production Commissioner, Govt. of U.P. was the Chief Guest. He highlighted the role of sugarcane in the economic development of U.P. He expressed the concern of the Government for the welfare of sugarcane farmers and the sugar industry of the State. He expressed his satisfaction over the improved recovery during the current crushing season and urged the sugarcane farmers to adopt innovative technologies to maximize income. Explaining the role of environment as well as of variety in improving sugar recovery, Dr. Bakshi Ram, Director, ICAR-SBI, Coimbatore credited the higher recovery of 0.36% to the adoption of the improved sugarcane variety, Co 0238 in U.P. Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow welcomed the participants and presented a brief accomplishments of the Institute.

Seminar on "Improving Productivity and Quality of Hybrid Rice and Sugarcane in U.P."

One Day Seminar on "Improving Productivity and Quality of Hybrid Rice and Sugarcane in U.P." was jointly organized by *Krishi Evam Gramin Vikas Sewa Samiti*, Lucknow and ICAR-IISR, Lucknow on December 18, 2016. Sh. Ram Naik ji, Hon'ble Governor of U.P. urged the scientists to discuss how the technology developed by them could be beneficial for the farmers and how the technology developed in the laboratory to be disseminated to the farmers. He urged the scientists to discuss how the consumption of improved jaggery can be increased among the masses. He also emphasized that the scientists should also work on diversified uses of sugarcane to make sugarcane cultivation more profitable. Welcoming the Chief Guest and other dignitaries, Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow also advocated for more blending of ethanol in petrol in future and accruing its benefits to the sugarcane farmers, sugar industry and the Indian economy.

The technologies developed by the Institute including new varieties, crop production technology,

bio-control of insect-pests and diseases, agricultural machineries developed for mechanization of sugarcane farming and jaggery manufacturing was showcased to the Hon'ble Governor. He took keen interest in sugarcane machineries, production and protection technologies and advancements made in jaggery manufacturing and appreciated the efforts of the ICAR-IISR Scientists in developing the improved technology of sugarcane cultivation which has helped in making country self reliant in sugar production.

Hindi Pakhwara

Hindi Pakhwara was celebrated at the Institute during Sept. 14-30, 2016. Prof. Alok Dhawan, Director, CSIR-IITR, Lucknow was the Chief Guest on the occasion. Prof. Dhawan urged the Scientists and staff to do their daily work in Hindi. Prof. Dhawan added that Hindi has helped in unity and integrity of the country as a contact language. Dr. A.D. Pathak, Director, ICAR-IISR requested all to do the maximum work in Hindi. During the Hindi *Pakhwara*, several competitions like review of the work done in Hindi during the year, Hindi typing in unicode, presentation of Institute activities in 20 slides, noting, order writing, extempore talk,

Antakchhari and quiz completition based on general knowledge in Hindi were organized.

Hindi Workshops

Four Hindi Workshops were organized during the year 2016-17 viz., June 28, 2016; August 23, 2016; December 20, 2016 and March 31, 2017 for the officers and employees of the Institute. Number of lecturers was delivered by the experts for more use of official language in the office work.

Meeting of Nagar *Rajbhasha Karyanvayan Samiti* (*Karyalaya 3*)

The First Meeting of Nagar *Rajbhasha Karyanvayan Samiti* (*Karyalaya 3*) for the year 2016 was organized at the Institute on June 28, 2016 under the chairmanship of Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow. The second meeting was held at the Institute on December 16, 2016 under the chairmanship of Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow. The meeting was attended by Heads of the Departments of 50 member offices. Many member offices were awarded for various works in different categories.

CHAPTER 20

Distinguished Visitors

Name and Designation	Date
Sh. Rajnath Singh, Hon'ble Home Minister, Govt. of India, New Delhi	April 02, 2016
Sh. Kaushal Kishore, Hon'ble Member of Parliament, Mohanlalganj	April 02, 2016
Dr. U.S. Gautam, Director, ICAR-ATARI (Zone IV), Kanpur	April 02, May 26, December 3, 2016 and January 27, 2017
Dr. Yashvir Tyagi, Ex. Professor and Head (Economics), University of Lucknow	April 21, 2016
Dr. J.B. Chaudhary, Ex. Vice-Chancellor, GBPUA&T, Pantnagar	April 25-27, 2016
Dr. N. Vijay Nair, Ex-Director, ICAR-SBI, Combitore	April 25-27, 2016
Dr. R.K. Samanta, Ex. Vice-Chancellor, BCKVV, WB	April 25-27, 2016
Sh. Pravir Kumar, IAS, Agricultural Production Commissioner, Govt. of U.P., Lucknow	April 29, 2016
Sh. Narendra Mohan, Director, NSI, Kanpur	April 29, 2016
Dr. Bakshi Ram, Director, ICAR-SBI, Coimbatore	April 29, 2016 and January 23, 2017
Dr. Ram Moorty Singh, President, NISSTA, Lucknow	April 29, 2016 and January 23, 2017
Sh. Anil Kumar Shukla, Secretary, NISSTA, Lucknow	April 29, 2016
Sh. Ram Naik, Hon'ble Governor of U.P., Lucknow	May 26, 2016 and December 18, 2016
Dr. A.K. Singh, DDG (Ag. Extension), ICAR, New Delhi	May 26 and December 3, 2016
Dr. Mangala Rai, Ex. Secretary, DARE & DG, ICAR	May 26, 2016
Dr. Gaya Prasad, Vice-Chancellor, SVPUA&T, Meerut	May 26, 2016
Dr. K.M.L. Pathak, Vice-Chancellor, DUVASU, Mathura	May 26, 2016
Dr. S.L. Goswami, Vice-Chancellor, BUA&T, Banda	May 26, 2016
Dr. S. Rajan, Director, ICAR-CISH, Lucknow	May 26, 2016; September 30, 2016 and February 16, 2017
Dr. Ravindra Kumar, Director, ICAR-NBFGR, Lucknow	May 26, 2016
Dr. Mathura Rai, Ex. Director, ICAR-IIVR, Varanasi	May 26, 2016
Dr. Trilochan Mohapatra, Secretary, DARE and DG, ICAR, New Delhi	June 8, 2016
Dr. J.K. Jena, DDG (Fisheries), ICAR, New Delhi	June 8, 2016
Dr. S.K. Chaudhary, ADG (Soils), ICAR, New Delhi	June 8, 2016
Dr. P.C. Sharma, Director, ICAR-CSSRI, Karnal	June 8, 2016
Dr. A.N. Mukhopadhyay, Ex. Vice-Chancellor, AAU, Jorhat	June 8, 27 and 29, 2016

Dr. R.K. Singh, ADG (CC), ICAR, New Delhi	June 29, 2016 and January 23, 2017
Dr. N. Balasundaram, Ex. Director, ICAR-SBI, Coimbatore	June 29, 2016
Dr. D.G. Hapase, Ex-Director, VSI, Pune	June 29, 2016
Dr. A.S. Patil, Ex. Director, VSI, Pune	June 29, 2016
Dr. Surendra Singh, Ex. Project Coordinator (FIM), ICAR-CIAE, Bhopal	June 29, 2016
Sh. S.K. Singh, Additional Secretary, DARE and Financial Adviser, ICAR, New Delhi	September 30, 2016
Sh. Devendra Kumar, Director (Finance), ICAR, New Delhi	September 30, 2016
Dr. A.K. Vasishtha, ADG (PIM) ICAR, New Delhi	September 30, 2016
Dr. K.K. Lal, Director, ICAR-NBFGR, Lucknow	September 30, 2016
Dr. J.S. Sandhu, DDG (Crop Science), ICAR, New Delhi	November 11, 2016
Dr. Kirti Singh, Ex. Chairman, ASRB, New Delhi	December 3-4, 2016
Dr. B. Singh, Director, ICAR-IIVR, Varanasi	December 3, 2016
Sh. Gyan Singh, Director (Agriculture), U.P., Lucknow	December 18, 2016
Sh. B.K. Yadav, Managing Director, U.P. Cooperative Sugar Mill Federation, Lucknow	December 18, 2016
Dr. M.P. Pandey, Ex. Vice Chancellor, IGKVV, Raipur & BAU, Ranchi	December 18, 2016
Dr. S.R. Singh, Ex. Vice-Chancellor, RAU, Pusa (Bihar)	December 18, 2016
Dr. R.P. Singh, Ex. Vice Chancellor, MPUA&T, Udaipur	December 18, 2016
Dr. P.S. Pathak, Ex. Director, ICAR-IGFRI, Jhansi	December 18, 2016
Dr. R.P. Singh, Director, *Krishi Evam Gramin Vikas Sewa Samiti*, Lucknow	December 18, 2016
Sri Vipin Kumar Dwivedi, Cane Commissioner, Sugarcane Development and Sugar Industry, Govt. of U.P.	January 23 and February 6, 2017
Dr. S. Solomon, Vice-Chancellor, CSAUA&T, Kanpur	January 27 and February 06, 2017
Dr. B.L. Sharma, Director, UPCSR, Shahjahanpur	February 06, 2017
Dr. M.M. Godbole, Professor, (Molecular Medicine & Biotechnology), SGPGIMS, Lucknow	February 16, 2017
Dr. Narayan Prasad, Professor (Nephrology), SGPGIMS, Lucknow	February 28, 2017



CHAPTER 21

Personnel (As on March 31, 2017)

Director	:	Dr. A.D. Pathak
Crop Improvement		
Principal Scientist & Head	:	Dr. D.R. Malaviya
Principal Scientist (Plant Breeding)	:	Dr. Jyotsnendra 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
Senior Scientist (Agril. Biotechnology)	:	Dr. Sanjeev Kumar
Senior Scientist (Plant Breeding)	:	Dr. Ashutosh Kumar Mall
Scientist (Agricultural Biotechnology)	:	Sh. Ranjit Singh Gujjar (On study leave)
Chief Technical Officer	:	Smt. Hemlata Madhok
Senior Technical Officer	:	Mr. Raghvendra Kumar
	:	Mr. Ram Murty
	:	Dr. Ram Kishor
	:	Mr. S.N. Srivastava
Crop Production		
Principal Scientist & Head	:	Dr. V.P. Singh
Principal Scientist (Agronomy)	:	Dr. K.P. Singh
	:	Dr. T.K. Srivastava
	:	Dr. S.N. Singh
	:	Dr. A.K. Singh
	:	Dr. K.K. Singh
	:	Dr. Chandra Gupta
Principal Scientist (Agril. Extension)	:	Dr. R.S. Dohare
Senior Scientist (Agronomy)	:	Dr. V.P. Jaiswal
	:	Dr. A.P. Dwivedi
	:	Dr. V.K. Singh
Senior Scientist (Soil Science)	:	Dr. S.R. Singh
Scientist SS (Soil Science)	:	Dr. Ram Ratan Verma
Assistant Chief Technical Officer	:	Mrs. Asha Gaur
	:	Dr. R.K. Singh
	:	Mr. B.B Singh
Technical Officer	:	Mr. Anil Kumar Singh
	:	Mr. Sanjay Gautam
Crop Protection		
Principal Scientist & Head	:	Dr. M.R. Singh
Principal Scientist (Plant Pathology)	:	Dr. S.K. Duttamajumder

	:	Dr. Anil Kumar Singh
	:	Dr. Dinesh Singh
Principal Scientist (Agril. Entomology)	:	Dr. S.N. Sushil
	:	Dr. Arun Baitha
	:	Dr. Sharmila Roy
Sr. Scientist (Plant Pathology)	:	Dr. Deeksha Joshi
Scientist (Plant Pathology)	:	Mr. S.K. Holkar
Chief Technical Officer	:	Dr. D.C. Rajak (On deputation)
Assistant Chief Technical Officer	:	Mr. I.P. Maurya
	:	Mr. M.P. Sharma
	:	Mr. Devendra Singh
Senior Technical Officer	:	Mrs. Pramila Lal
Agricultural Engineering		
Principal Scientist & Head	:	Dr. A.K. Singh
Principal Scientist (FMP)	:	Dr. R.D. Singh
	:	Dr. S.I. Anwar
Principal Scientist (SWCE)	:	Dr. Rajendra Gupta
Senior Scientist (FMP)	:	Er. Sukhbir Singh
Senior Scientist (AS &PE)	:	Dr. Dilip Kumar
Assistant Chief Technical Officer	:	Mr. M.H. Ansari
	:	Mr. Suresh Kumar Kushwaha
	:	Mrs. Mithilesh Tiwari
	:	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. Julianus Minz
	:	Mr. Someshwar Mishra
	:	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
Chief Technical Officer	:	Mr. Sanjay Bhatnagar
Assistant Chief Technical Officer	:	Mr. C.P. Singh
	:	Mrs. Anita Sawnani (on study leave)
Technical Officer	:	Mr. R.K. Singh

PME Cell & Institute Technology Management Unit		
Nodal Officer & Incharge	:	Dr. A.K. Sharma
Chief Technical Officer	:	Mr. Brahm Prakash
Assistant Chief Technical Officer	:	Mr. Atul Kumar Sachan
AKMU		
Principal Scientist & Incharge	:	Dr. Rajesh Kumar
Principal Scientist (Agril. Economics)	:	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
Senior Scientist (Agril. Extension)	:	Dr. Kamta Prasad
	:	Dr. Barsati Lal
Chief Technical Officer	:	Mr. Nar Singh
Assistant Chief Technical Officer	:	Dr. Om Prakash
	:	Mr. A.K. Singh
Juice Lab		
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. Vinod Kumar 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 Section		
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. Vishwanath Ram
	:	Mr. J.P. Pandey
	:	Mr. A.P. Dubey
Krishi Vigyan Kendra		
Principal Scientist & Head	:	Dr. S.N. Singh
SMS (Animal Science)	:	Dr. Rakesh Kumar Singh
SMS (Home Science)	:	Dr. Veenika Singh
SMS (Plant Protection)	:	Dr. Deepak Rai
SMS (Horticulture)	:	Dr. Vivekanand Singh
SMS (Extension)	:	Mr. Yogendra Pratap Singh
Technical Officer	:	Mrs. Neelam Singh

Rajbhasha Prakoshtha		
Principal Scientist & In-charge	:	Dr. A.K. Sah
Technical Officer	:	Mr. Abhishek Kumar Singh
Art & Photography		
Principal Scientist & In-Charge	:	Dr. A.K. Sharma
Chief Technical Officer	:	Mr. Vipin Dhawan
Assistant Chief Technical Officer	:	Mr. Y.M. Singh
Senior Technical Officer	:	Mr. Avadhesh Kumar Yadav
Dispensary		
In-charge	:	Mr. Ratnesh Kumar
Assistant Chief Medical Officer	:	Dr. S.K. Sethi
Technical Officer	:	Mr. D.N. Sinha
Library		
Principal Scientist & In-Charge	:	Dr. L.S. Gangwar
Assistant Chief Technical Officer	:	Mr. Ghanshyam Ram
Senior Technical Officer	:	Mr. R.N.P. Bharti
In-Charge, Seed Production Unit	:	Dr. Sanjeev Kumar
In-Charge, Vehicle	:	Mr. Raj Kumar
In-Charge, Landscaping	:	Mr. Shridhar Tiwari
In-Charge, Guest House	:	Mr. Ratnesh Kumar
Security Officer	:	Mr. C.P. Prajapati
IISR Regional Centre, Motipur (Bihar)		
Senior Scientist & In-charge	:	Dr. A.K. Mall
IISR Biological Control Centre, Pravarnagar (Maharashtra)		
Nodal Officer	:	Dr. M.R. Singh
Scientist (Nematology)	:	Mr. Yogesh Kumar Thorat
Administration		
Senior Administrative Officer	:	Mr. Ratnesh Kumar
Finance & Accounts Officer	:	Mr. Raja Ram
Administrative Officer	:	Mr. Darvesh Kumar
Assistant Administrative Officer	:	Mr. R.K. Yadav
	:	Mr. V.P. Tiwari
	:	Mr. S.K. Bagchi
	:	Mr. Anand Mohan Srivastava
Private Secretary	:	Mr. Rajeev Arora
	:	Mr. Prem Chandra

Promotions

Joining

RMP

Dr. A.D.Pathak joined as Director, ICAR-IISR, Lucknow on August 4, 2016.

Scientists

- Dr. Radha Jain joined as Head, Division of Plant Physiology & Biochemistry on July 22, 2016
- Mr. Ranjeet Singh Gujjar joined as Scientist (Agril. Biotechnology) on transfer from ICAR-IIVR, Varanasi on June 29, 2016.
- Dr. S.K. Shukla joined as Project Coordinator, AICRP on Sugarcane on August 27, 2016
- Dr. A.P. Dwivedi joined as Senior Scientist (Agronomy) on transfer from ICAR-ATARI, Zone VII, Jabalpur on November 21, 2016.
- Dr. Sharmila Roy joined as Principal Scientist (Entomology) on transfer from ICAR-CISH, Lucknow on March 20, 2017.
- Sh. Sanjai Kumar Yadav joined as Scientist (Agronomy) on transfer from ICAR-CPRI Regional Station, Patna on March 21, 2017.
- Dr. Barsati Lal joined as Senior Scientist (Agril. Extension) on transfer from ICAR-CISH, Lucknow on March 23, 2017.

Technical

- Sh. Rajiv Ranjan Rai joined as Assistant Chief Technical Officer on transfer from ICAR-NRC on Litchi, Muzaffarpur (Bihar) on February 1, 2017.
- Sh. A.P. Dubey joined as Technical Officer on transfer from ICAR-National Organic Farming Research Institute, Gangtok on February 14, 2017.
- Sh. Dhirendra Kumar joined as Technician (T-1) on transfer from ICAR-IVRI, Bareilly on March 28, 2017.

Administration

- Mr. Darvesh Kumar joined as Administrative Officer on transfer from ICAR-Directorate of Groundnut Research, Junagadh on May 18, 2016.
- Mr. Ashutosh Sahi joined as Assistant on transfer from ICAR Research Complex for the North Eastern Region, Umiam (Arunachal Pradesh Centre– Baser) on October 3, 2016.

Transfer

- Dr. Ishwar Singh, Senior Scientist (Agronomy), ICAR-IISR, Lucknow was transferred to ICAR-NBPGR, New Delhi on June 20, 2016.

Superannuation

Scientists

- Dr. O.K. Sinha, Project Coordinator, AICRP on Sugarcane was superannuated on June 30, 2016
- Dr. A.K. Srivastava, Principal Scientist (Plant Physiology) was superannuated on December 31, 2016.
- Dr. Raman Kapur, Principal Scientist (Plant Breeding) was superannuated on December 31, 2016

Technical

- Sh. G.K. Gupta, Chief Technical Officer (Library) was superannuated on June 30, 2016.
- Sh. B.L. Maurya, Technical Officer, Division of Crop Protection was superannuated on June 30, 2016.
- Sh. Jasbeer Singh, Assistant Chief Technical Officer, Division of Agricultural Engineering was superannuated on July 31, 2016.
- Sh. Prahalad Narain, Technical Officer (Driver) was superannuated on July 31, 2016.
- Sh. Ram Sewak, Senior Technical Officer, Division of Crop Improvement was superannuated on August 31, 2016.
- Sh. Pyare Lal, Sr. Technician, Division of Agril. Engineering was superannuated on September 30, 2016.
- Sh. Keshav Prasad, Sr. Technical Assistant, Farm Section was superannuated on September 30, 2016.
- Smt. Namita Arya, Assistant Chief Technical Officer, Division of Plant Physiology & Biochemistry was superannuated on September 30, 2016.
- Sh. Ram Kumar, Assistant Chief Technical Officer, Division of Crop Improvement was superannuated on September 30, 2016.
- Sh. Pyare Lal, Technical Assistant, Division of Plant Physiology & Biochemistry was superannuated on January 31, 2017.
- Sh. V.N. Mehrotra, Technical Officer, Division of Agricultural Engineering was superannuated on January 31, 2017.
- Dr. Anoop Singh Sachan, Senior Technical Officer, Division of Crop Protection was superannuated on January 31, 2017.

Administration

- Smt. Raj Shankar, Assistant was superannuated on September 30, 2016.

- Sh. Ram Das, Assistant Administrative Officer was superannuated on May 31, 2016.

Skilled Supporting Staff

- Sh. Lalloo, SSS was superannuated on August 31, 2016.

Promotions

Scientist

- Dr. Rajenda Gupta, Senior Scientist (SWCE) promoted to Principal Scientst w.e.f. December 17, 2014.

Administration Staff

- Sh. Anand Mohan Srivastava, Assistant promoted to Assistant Administrative Officer w.e.f. June 1, 2016.
- Sh. Ramesh Prasad Verma, Upper Division Clerk promoted to Assistant w.e.f. June 1, 2016.

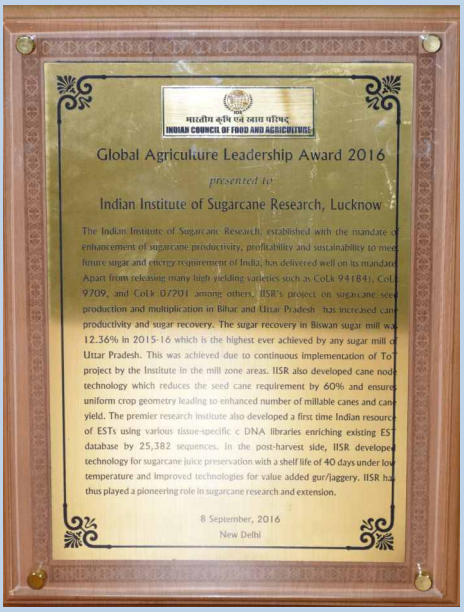
Technical

- Sh. Ashish Singh Yadav, Technical Assistant promoted to Senior Technical Assistant w.e.f. March 1, 2016.
- Sh. Rajendra Kumar Singh, Senior Technical Assistant promoted to Technical Officer w.e.f. May 27, 2016.
- Sh. Jagjeet Singh, Senior Technical Assistant promoted to Technical Officer w.e.f. October 1, 2016.
- Sh. Patan Deen, Technical Assistant promoted to Senior Technical Assistant w.e.f. June 29, 2016.
- Sh. Deep Chand, Technical Assistant promoted to Senior Technical Assistant w.e.f. June 29, 2016.
- Sh. Raj Nath Sharma, Technical Assistant promoted to Senior Technical Assistant w.e.f. June 29, 2016.
- Sh. Brij Kishore, Technical Assistant promoted to Senior Technical Assistant w.e.f. June 29, 2016.
- Sh. Suresh Kumar, Senior Technical Assistant promoted to Technical Officer w.e.f. June 29, 2016.
- Sh. Pyare Lal, Senior Technician promoted to Technical Assistant w.e.f. October 20, 2016.
- Sh. Omkar Nath, Senior Technician promoted to Technical Assistant w.e.f. October 20, 2016.
- Sh. Triloki Prasad got 3rd MACP and promoted in GP ₹ 2400/- w.e.f. October 28, 2016.
- Smt. Promila Lal, Technical Officer promoted to Senior Technical Officer w.e.f. February 24, 2006.
- Sh. M.P. Sharma, Technical Officer promoted to Senior Technical Officer w.e.f. July 1, 2010 and promoted to Assistant Chief Technical Officer w.e.f. July 1, 2015.
- Sh. Ram Murti, Technical Officer promoted to Senior Technical Officer w.e.f. November 17, 2007.
- Smt. Santosh Gautam, SSS promoted to Technician w.e.f. March 15, 2017.
- Sh. R.N. Bharti, Technical Officer promoted to Senior Technical Officer w.e.f. July 15, 2015.
- Sh. I.P. Maurya, Technical Officer promoted to Senior Technical Officer w.e.f. July 1, 2010 and promoted to Assistant Chief Technical Officer w.e.f. July 1, 2015.
- Sh. Vipin Dhawa, Asstt. Chief Technical Officer promoted to Chief Technical Officer on January 1, 2016.
- Sh. Akhilesh Kumar Singh, Senior Technical Officer promoted to Assistant Chief Technical Officer w.e.f. January 7, 2016.
- Sh. Adil Zubair, Senior Technical Officer has been promoted to Assistant Chief Technical Officer w.e.f. February 24, 2011.
- Sh. Devendra Singh, Senior Technical Officer has been promoted to Assistant Chief Technical Officer w.e.f. April 11, 2016.

CHAPTER 22

Meteorological Data

Month	Temperature (°C)		RH (%)		Rainfall (mm)	Rainy days	Duration of sunshine	Wind speed (km/h)
	Maximum	Minimum	0718 Hrs.	1418 Hrs.				
April 2016	40.2	23.3	46.8	16.1	0.0	0	10.0	9.5
May 2016	39.0	25.4	64.5	35.5	39.6	4	9.8	7.0
June 2016	37.9	27.6	77.4	51.0	92.4	5	8.1	5.9
July 2016	33.4	26.3	92.0	76.6	219.6	17	4.3	3.0
August 2016	33.7	25.7	89.7	73.2	243.4	12	6.5	3.0
September 2016	33.4	25.2	92.2	79.0	202.4	8	6.2	3.2
October 2006	33.5	19.7	92.2	45.9	54.6	2	8.4	2.8
November 2016	28.6	11.9	95.4	42.1	0.0	0	6.6	1.7
December 2016	22.2	9.1	97.5	61.7	0.0	0	2.2	0.8
January 2017	22.0	7.8	94.6	51.5	16.5	2	5.7	1.4
February 2017	25.8	10.3	91.3	36.3	0.4	0	6.3	2.6
March 2017	31.8	17.1	75.8	25.3	5.4	1	9.3	5.0
Annual	**31.8**	**19.1**	**84.1**	**45.5**	**874.3**	**51**	**6.95**	**3.8**



ICAR-Indian Institute of Sugarcane Research
Lucknow - 226 002, Uttar Pradesh, India
Tel: +91-522-2480726, 2961318; Fax: +91-522-2480738
E-mail: director.sugarcane@icar.gov.in
www.iisr.nic.in