ICAR-Indian Institute of Sugarcane Research
Lucknow

ANNUAL REPORT 2015-16

A glimpse of foundation stone laying ceremony of

Farmers Training Home & Jaggery Training Unit

at ICAR-IISR Regional Centre, Motipur (Bihar)

(March 5, 2016)

वार्षिक प्रतिवेदन
Annual Report

2015-16

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Preface

Sugarcane is an important component of the economy of many tropical and subtropical countries including India. With an annual sugarcane production of approximately 350 million tonnes and 25 million tonnes of sugar, India has been able to attain self-sufficiency in sugar production, despite having the largest sugar consumption base in the world. Sugarcane has become even more important crop due to increasing demand of bioenergy from today's society. The demand of sugar is expected to increase from present 25.10 MT to 36 MT and that of ethanol from 2170 ML to 8800 ML by the year 2030. This paradigm shift of recognizing sugarcane as an important feedstock for second generation ethanol production using bagasse and other cellulosic material like trash invites the attention of scientists to look in the novel avenues associated with it. Keeping all this in view, there is a need to increase sugarcane production, productivity and sugar recovery from 341 to 500 MT, 70 t/ha to more than 100 t/ha and 10% to more than 11%, respectively.

To attain such a greater challenge, genetic barrier for productivity, profitability and sustainability needs to break down by developing high yielding, high sugar, location specific, stress tolerant and better water/nutrient use efficient varieties. It also calls for high biomass, moderate sugar varieties/energy canes that can serve as feed-stocks for bio-ethanol production and co-generation. Identification of high sugar and red rot resistance in sugarcane through genomics and proteomics approaches and multidisciplinary research to identify candidate genes/RGAs governing red rot resistance and drought tolerance needs to be intensified. Quality sugarcane seed production using conventional and non conventional methods is still a priority. Disease-free and effective seed production to replace old varieties through micro-propagation needs to be started in PPP mode. Climate change poses a threat to the control of pest and disease invasions. Climate resilient plant protection techniques especially with reference to the yield losses, insect vectors, sources of resistance and the effect of abiotic stresses on disease occurrence needs to be developed. The Institute has identified many efficient bio-control agents for major insect pests. However, selection and identification of novel strains of bio-agents which are better adapted to the changing environmental scenario needs to be focused. Rhizospheric modules to improve soil quality and crop productivity, computer-based (GIS) precision farming strategies for site specific sugarcane management are some other strategies which needs to be adopted. This Institute has done tremendous research in developing sugarcane machines and implements. Institute-made cutter planters and trench openers are able to change the sugarcane farming of the State. However, there is need to develop machine for inter-culturing and sowing of inter-crops in plant as well as in ratoons. Sugarcane harvester more suitable for Indian conditions also needs to be developed. Technological interventions are also needed for the production of by-products of sugarcane for enhanced profitability of sugarcane farmers such as hygienic and modern Jaggery units with state-of-the-art technologies for processing of cane/cane juice, value addition for overcoming malnutrition, packing and storage. Institute also needs to focus on entrepreneurship development in the field of quality seed production, micro-propagation facilities, bio-control units, modern and hygienic Jaggery units and up keep of Sugarcane farming related machine.

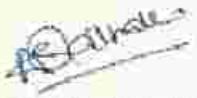
It gives me immense pleasure to present the Institute's Annual Report for the year 2015-16 which highlights the research efforts of ICAR-IISR made in the target areas. In crop production research, emphasis was laid on deep tillage, sub soiling, seed priming, assessment of inputs on organic sources, nutrient, weed and water management, and the use of plant growth regulators. In crop protection research, surveys of incidence of diseases and insect pests, screening and evaluation of genotypes against YLD, red rot and other diseases, effect of bio-control agents, and

of *Trichoderma* in managing the diseases was carried out. Plant Physiology and Biochemistry research was carried out on seed priming, transcriptome analysis and post harvest losses. The highlight of agricultural engineering research was the development of "Deep furrow sugarcane cutter planter". Other developments include production and distribution of around 5500 qt. of quality seed cane, demonstration of technologies in Bihar, Western Uttar Pradesh, Uttarakhand and Maharashtra. A number of successful frontline demonstrations were conducted on farmers' fields and crop advisories were issued.

In this report, a great deal of research achievements has been summarized which provide ample hope for meeting the challenging targets for increased cane and sugar productivity. Efforts have been made to reduce the cost of seed as well as crop management practices by making use of improved planting methods and planting machines, agro-techniques for sustainable farming such as land use efficiency through intercropping, water use efficiency and ratoon management. I hope that the information in this report about the technologies developed would help the farmers as well as industry in the long run.

The all-round growth and development of the Institute has been possible with the able guidance, encouragement and continuous support received from Dr. Trilochan 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 of Dr. R.K. Singh, Assistant Director General (Commercial Crops) in carrying out various activities is highly acknowledged. I also acknowledge the contributions made under the guidance of my predecessors Dr. O.K. Sinha and Dr. T.K. Srivastava as Acting Directors of the Institute during the year.

I would like to appreciate Drs. M.R. Singh, Amaresh Chandra, S.K. Shukla, A.K. Singh, all Heads of Divisions, for their sincere efforts in compiling and editing the report of their respective divisions. The sincere efforts of Dr. A.K. Sharma, Principal Scientist & Incharge PME and Shri Brahm Prakash, Chief Technical Officer in compiling, editing and bringing out the report are highly appreciated. I also thank Mr. Mohammad Ashfaque, Research Associate for his help in bringing out the report in the present shape.



(A.D. Pathak)
Director

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Executive Summary

Crop Improvement

- A total of 13 sugarcane clones *viz.*, CoLk 15201, CoLk 15202, CoLk 15203, CoLk 15204, CoLk 15205, CoLk 15206, CoLk 15207, CoLk 15208, CoLk 15209, CoLk 15466, CoLk 15467, CoLk 15468 and CoLk 15469 were recommended for multilocation trials under AICRP-Sugarcane.
- The collection of 339 genotypes consisting of *Saccharum officinarum*, *S. barberi*, *S. sinense*, ISH clones, IkshuISH clones, LG selections, commercial hybrids, somaclonal variants *etc.*, was maintained. The collection has 162 commercial hybrids, 51 ISH and IkshuISH lines, 71 LG clones and 30 species level genotypes.
- Ten disease resistance gene analogs (RGAs) using the conserved motifs of the resistance genes were identified using homology-based PCR to target the nucleotide binding site (NBS) conserved regions from one red rot resistant genotype BO 91 and one red rot susceptible genotype CoJ 64.
- Out of a subset of 240 clones phenotyped from a population of CoLk 7901 self, approximately 47% of the clones exhibited mean Pol% juice values from 14-17 % during the peak period (January). A few of the clones showed good vigour.
- Linkage disequilibrium based study using a panel of 119 sugarcane genotypes fingerprinted for 944 SSR alleles identified four marker-trait associations (MTAs) for resistance to red rot that explained 10-16% trait variation.
- Around 20,000 micropropagated plants of two varieties *viz.*, CoLk 9709 and Co 05011 were transplanted and completed one cycle of multiplication in the field as genetically uniform seed cane.
- In Accredited Test Laboratory (ATL) for genetic fidelity and virus indexing of tissue culture raised plants, around 700 samples of tissue culture mother stock and samples from tissue culture batch plants of sugarcane and banana were tested for genetic fidelity and virus indexing.
- A statistical study inferred that there was a quantum jump in cane yield due to genetic improvement in last twenty five years of sugarcane breeding programme in all the five zones of AICRP on Sugarcane.
- Around 7,400 q of seed cane was produced, out of which, 5,500 q seed cane of improved varieties of sugarcane was lifted by sugar mills for its distribution to farmers.

Sugarbeet Research

- Fifty three germplasm lines of sugarbeet comprising of inbreds, varieties, composites and elite selections were raised. Nearly 40 kg of sugarbeet seed of the indigenous varieties and the open-pollinated IISR variety, LS-6 was produced at Sugarbeet Breeding Outpost, Mukteswar, Uttarakhand.
- Economics of commercial cultivation of sugarbeet in Punjab state was worked out at ₹ 66,000 to ₹ 73,000 per hectare with net returns of ₹ 68,000 to 75,000 per hectare.

Crop Management

- Deep tillage and subsoiling (ratoon crop) followed by harrowing before sugarcane planting produced the highest number of millable canes (132,100/ha), cane weight (973.3 g), and an increase of 28.10% in ratoon cane yield (117.6 t/ha) over the control. Trash mulching in ratoon crop with application of microbial consortia (*Trichoderma*, *Gluconacetobacter* and *Pseudomonas*) improved growth and yield attributes besides improving the soil health parameters.
- Evaluation of agronomic performance of three mid-late genotypes of sugarcane revealed that genotype CoPb 08217 was superior over CoLk 09204 and CoS 0835 in respect of cane and ratoon yield as well as juice quality.
- In a thrice-replicated RBD experiment consisting of eight treatments on the impact of the use of plant growth regulators (PGRs) on yield and quality of sugarcane, the treatment comprising planting of setts after overnight soaking in 100 ppm ethrel solution and GA_3 spray at 90, 120 and 150 days after planting recorded significantly higher cane yield (96.67 t/ha). The same treatment also recorded higher cane length (243 cm), diameter (2.16 cm), weight (910 g) and number of millable cane (146.8 thousand/ha). However, the cane diameter and juice quality parameters were not affected significantly due to use of plant growth regulators in sugarcane.

Nutrient Management

- The cane yield was significantly higher (69.6 t/ha) in the treatment of 150 kg N/ha over 100 kg N/ha due to improvement in NMC, cane length and cane weight. However, cane length and cane weight was statistically at par with 150 kg N/ha and 100 kg N/ha. Application of potassium at 30 kg K_2O/ha significantly enhanced cane yield over control. Further increase in potassium level could not improve cane yield to the level of significance.
- The application of phosphorus was found effective up to the level of 30 kg P_2O_5/ ha. The application of 15 kg Zn/ha along with 30 and 60 kg P_2O_5/ha enhanced cane yield over sole treatments. However, application of Zn alone could not influence the cane yield. A negative interaction between P and Zn was observed at higher level of zinc application.
- The highest rate of stubble sprouts (92.6%) was observed under the treatment of organic application. The highest number of tillers (254.9 thousand/ha at 120 days after initiation), number of millable canes (167.9 thousand/ha), cane yield (91.7 t/ha) and sugar yield (11.07 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. The yield attributing characters also improved significantly. The quality parameters were also improved with application of FYM and biofertilizers.

Water Management

- Significantly highest shoot count (161.3 thousand/ha at 150 DAP), number of millable canes (123.9 thousand/ha), cane yield (59.9 t/ha) and sugar yield (8.82 t/ha) were recorded with the discharge of 10 lps + 85 % cut off length. It also resulted in the highest IWUE of 1755.9 and 2194.6 kg/ha-cm in 50 m and 75 m furrow length, respectively. This combination saved 40.9% of total irrigation water as compared to border irrigation method (farmers' practice). Treatment of furrow-10 lps+85% cut off length and furrow-10 lps+75% cut off length showed the optimum discharge rate to move water towards tail end. Border irrigation method has shown a total irregular pattern of flow with ups and downs in head, middle and tail region along different depths resulting in inefficiency of water use.

Weed Management

- Application of sulfentrazone @ 1200 g a.i./ha registered 44.20% increase in cane yield, over atrazine + 2, 4-D (19.12%), glyphoate @ 1500 g a.i/ha (28.85%) and Sempra @ 90 g a.i./ha (12.58%).
- The conventional three-hoeing treatment achieved the highest cane yield (87.6 t/ha) followed by application of F 8072 @ 840+900 g a.i./ha and F 8072 @ 700+750 g a.i./ha. However, the weed density was recorded to be the lowest under the application of F 8072 @ 840+900 g a.i./ha.
- Pre-emergence application of either atrazine @ 2.0 kg/ha or sulfentrazone @ 0.8 kg/ha + trash mulching @ 10 t/ha post-emergence application of 2,4-D @ 1.0 kh/ha; or atrazine @ 2.0 kg/ha as PE fb hoeing at 60 DOP+ application of atrazine @ 1.0 kg/ha 2,4-D @ 1.0 kg/ha as PO could be used for effective weed control and for higher NMCs and cane yield.

Crop Protection

- Incidence of sugarcane diseases and insect-pests was surveyed in 12 sugar mill command areas of Uttar Pradesh, Bihar and Maharashtra. Incidendce of red rot was noticed mostly in old sugarcane varieties *i.e.*, CoLk 8102, CoS 8436, CoS 91269, and CoJ 85.
- Incidence of yellow leaf disease (YLD) was 10-40 per cent in 14 sugarcane varieties. Association of phytoplasma with YLD has been established through genomic DNA isolation. Incidence of thrips, *Fulmekiola serrata* was observed in varieties infected with disease.
- Serial thermotherapy of seed cane for two hours through MHAT at 50°C for three consecutive days was found effective against Yellow leaf disease (YLD). Sixty five germplasm/genotypes were screened against red rot (Cf 08 and Cf 09), smut and wilt. Thirty three genotype were MR to Cf 09 (Red rot Pathotype) and forty five genotypes were MR to Cf 08.
- A total of 126 *Trichoderma* isolates established from soil samples were maintained in laboratory and characterized for production of chitinase and cellulase enzymes and inhibitory secondary metabolites against *C. falcatum*. However, none of the isolates tested showed enzymatic and metabolite inhibitory activity comparable to the

previously identified promising isolates STr-83 and STr-108.

- There was no emergence of any new virulent pathotype in North West zone.
- Genotype CoS 11232 was found moderately susceptible (MS) to pathotype Cf 08 whereas susceptible (S) to pathotype Cf 09. Five genotype *viz.*, CoLk 11201, CoLK 11202, CoLk, 11206, CoPb 10182 and CoPb 11212 were found moderately resistant (MR) to pathotype Cf 08 and moderately susceptible (MS) to pathotype Cf 09. Out of eighteen genotypes tested for smut, seven genotypes were tolerant to smut. Seven genotypes recorded the natural incidence of Yellow Leaf Disease (YLD). Out of 21 genotypes evaluated at IISR RC, Motipur against red rot, sixteen genotypes were recorded moderately resistant (MR) reaction to both the pathotypes of red rot (Cf 07 and Cf 08).
- Incidence of top borer and cane borer was observed in Co 0238 and Co 0118. A severe attack of *Pyrilla perpusilla* was observed in Uttar Pradesh and Bihar. Incidence of Plassey borer was 16.25 and 6.42% in SA-04-245 (ISH & IGH lines) and Co 0233, respectively at ICAR-IISR RC, Motipur. Some parasitoids of cane borers such as *Cotesia flavipes* and *Stenobracon* were active with the parasitisation up to 9.8 per cent. In Maharashtra, incidence of early shoot borer (1-2%), army worm (10-18%) was found in CoM 0265.
- Incidence of top borer (III brood) was less than 10 per cent in CoJ 64, CoLk 94184 and CoS 94257. *Isotima javensis* and *Rhaconotus scirpophagae* were multiplied on field collected stored mature larve of top borer with success of 26.43 and 34.05%, respectively.
- Incidence of top borer II, III and IV brood was monitored in sugarcane agro-ecosystem and was 3.45 to 5.62%, 16.71 to 31.42 and 27.03 to 57.35 per cent, respectively. Incidence of root borer at shoot stage was low but in September, it was 40 to 55%. Incidence of internode borer and stalk borer was 4.76 to 34.28 and 2.38 to 16.67%, respectively.
- Observations on the control of root borer highlighted that insecticide Imidacloprid 40% + Fipronil 40% -80 WG @ 400 g a.i./ha and fertera @ 75 g a.i./ha were significantly superior over untreated control and other treatments with the incidence of 19.07 and 19.63%, respectively. Imidacloprid 40% + Fipronil 40% -80 WG @ 400 g a.i./ha has been found significantly superior over all the treatments with lowest sett damage (21.80%).
- The incidence of internode borer was low in plots intercropped with *jowar* and maize. The higher parasitisation by larval parasitoid, *Cotesia flavipes* was observed in plots raised with these crops.
- In an experiment to evaluate the effect of sex pheromones on incidence of borer pests of sugarcane, total number of male moths of top borer (II brood) caught in traps was 337 (56.17 moths/trap), total catch of top borer moth (III brood) was 166 (27.67 moths /trap) and of IV brood was only 77 (12.83/trap).
- Out of 12 mid-late maturing genotypes, only one genotype (CoLk 11206) was found MS (moderately susceptible). Out of seven genotypes, two genotypes *viz.*, CoLk 11202 and CoLk 11203 showed MS reaction.

Plant Physiology and Biochemistry

- Ethrel priming induced faster sink to source followed by source to sink transitions, fetching 60% higher and early establishment of sink strengths at 45 DAP. Foliar application of GA_3 at 90, 120 and 150 DAP led to increase in shoot population, increase in root weight and root hair development, LAI and changes in leaf angle, internodal numbers and length.
- *De novo* assembly statistics indicated a total of 2.0 lakh transcripts having about 1.3 lakh genes. Average length of contig was 707bps. Expression analysis indicated >1 lakh differentially expressing transcripts among two sets of samples. Of these, around 3000 transcripts were significantly differentially expressing.
- Twenty *Leuconostoc* samples were isolated from 34 sugarcane juice samples for post-harvest sucrose loss management. All the isolated strains exhibited growth at 15, 30 and 37°C but not at 4 and 45°C. To design species specific primers, 16S rDNA sequences of total of eight *Leuconostoc* species were used. A total of 12 species specific primers, both forward and reverse for six *Leuconostoc* species were designed. The primers were selected from the most varied regions of 16rDNA sequences of the *Leuconostoc* species.

Agricultural & Process Engineering

- Sugarcane-cum-potato planter was developed and field tested. Performance parameters were recorded.
- Multi-location trials of deep furrow sugarcane

cutter planter were conducted.

- Attachment of herbicide spraying was developed and integrated with deep furrow sugarcane cutter planter.
- Tractor operated sugarcane manager was field tested.
- A total of 27 prototypes (14 tractor operated- and 13 manually operated) were fabricated.
- A total of nine prototypes (six tractor operated and three manually operated) were supplied to different locations for multi-location trials.
- A cleaning-cum-washing machine for sugarcane for quality jaggery making is under testing in jaggery unit.

Extension & Economics

- Demonstrations of cane seed production technique were organised in Biswan sugar mill area.
- The field performance of Ratoon Promoter machine highlighted that the ratoon yield obtained for demo plots was 15.17% higher over yield obtained in conventional plots.
- The cost of sugarcane production and its processing has been increasing for farmers. The estimated cost of sugarcane production in U.P. ranges between ₹ 2,125 and ₹ 2,416/ tonne. The cost of sugar production in U.P. also varies from ₹ 28780 to ₹ 42,436/ tonne with ex-mill sugar price ₹ 31-37 per kg.
- Extent of area under pulse crops in sugarcane intensive tracts has negative correlation with the extent of sugarcane area expressed as percentage of net sown area under sugarcane crop in sugarcane intensive areas like U.P.
- Impact analysis study of mechanization efforts found that IISR developed sugarcane cutter planter is becoming popular in all size categories of farmers and about 2.63 lakh farmers are using this machine.

About the Institute

The ICAR-Indian Institute of Sugarcane Research (IISR), Lucknow was established in 1952 by the erstwhile Indian Central Sugarcane Committee for conducting research on fundamental and applied aspects of sugarcane culture as well as to co-ordinate research work done on this crop in different states of the country. The Government of India took over the Institute from the Indian Central Sugarcane Committee on January 1, 1954, and thereafter, it was transferred to the Indian Council of Agricultural Research (ICAR), New Delhi on April 1, 1969. The Institute is located in Lucknow, the capital city of Uttar Pradesh and conveniently situated at about 12 km from CCS Airport, Amausi and about 5 km from Lucknow Railway Station. The climate of the area is sub-tropical semi-arid type. Monthly average maximum temperature during April to June ranges from 36°C to 40°C and minimum temperature during November to February ranges from 7°C to 11.5°C. The annual average rainfall is around 880 mm.

Vision

An efficient, globally competitive and vibrant sugarcane agriculture

Mission

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

Mandate

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

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

(iii) Dissemination of technologies and capacity building.

Issues and Strategies

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

Issues

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

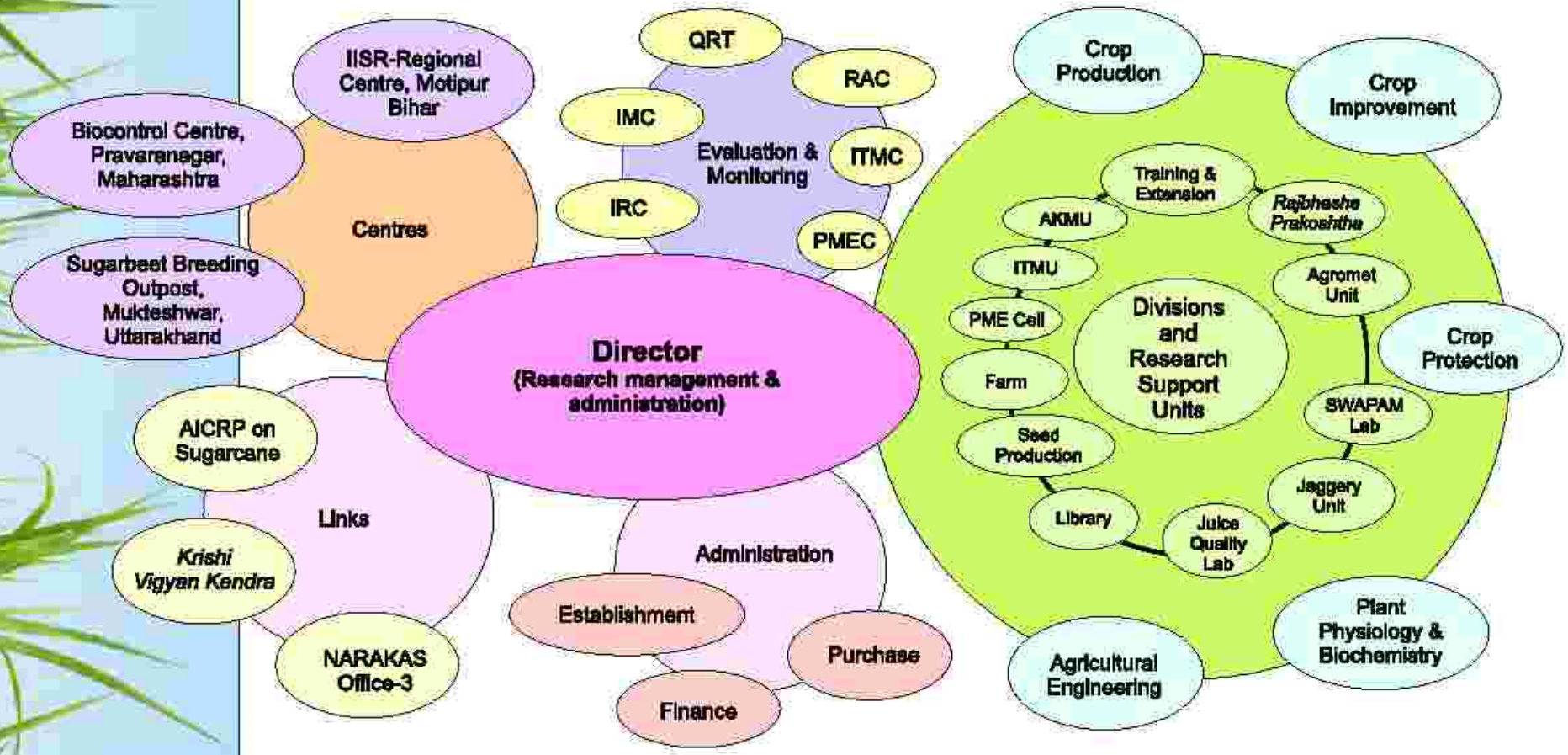
e. Mechanizing sugarcane farming

Arresting decline in factor productivity

a. Soil biological and nutritional dynamism

b. Carbon sequestering through cropping system

ICAR-Indian Institute of Sugarcane Research, Lucknow



Organizational Structure

Budget: 2015-16

Particulars	Non-Plan(₹ in lakh)		Plan (₹ in lakh)	
	Revised Estimate	Expenditure	Revised Estimate	Expenditure
ICAR - Indian Institute of Sugarcane Research	4496.56	4323.41	500.00	491.96
All India Coordinated Research Project on Sugarcane	-	-	922.28	911.98

Staff position as on March 31, 2016

Category	Sanctioned	Filled	Vacant
Scientific (including RMP)	73	56	17
Technical	134	108	26
Administrative	48	44	04
Supporting	72	23	49
Total	**327**	**231**	**96**

1

Genetic improvement of sugarcane for higher cane and sugar productivity

Sugarcane clones accepted for evaluation under AICRP on Sugarcane

Five early *viz.*, CoLk 15201, CoLk 15202, CoLk 15203, CoLk 15204 and CoLk 15205 and four mid late clones, CoLk 15206, CoLk 15207, CoLk 15208 and CoLk 15209 for the North Western Zone, while two early *viz.*, CoLk 15466 and CoLk 15467 and two mid late clones *viz.*, CoLk 15468 and CoLk 15469 were accepted for evaluation under multi-location trials of the North Central Zone in the AICRP (Sugarcane) Workshop held at Rajendra Agricultural University, Pusa, Bihar during December 15-16, 2015. The salient features of the accepted clones are given in Table 1.1.

Station Trial 2015-16

Under Station Trial 2015-16, sixteen entries were evaluated along with four control varieties, two each from the early and mid-late maturing groups.

The early-maturing potential commercial clones were LG 09487, LG 11001, LG 09113, LG 10435 and LG 11663 while LG 11645 and LG 09110 were found promising in the mid-maturity group. The best check in terms of cane and sugar yield was Co 0238. LG 09487, LG 08443 and LG 11001 showed high sugar content and can be used as parents in breeding sugarcane for quality.

Table 1.1. Sugarcane clones accepted for multi-location testing in North Western and North Central Zone

Clone (Selection number)	Group	Parentage	Performance at harvest			Red rot reaction	Zone*
			CCS (t/ha)	Cane yield (t/ha)	Sucrose (%)		
CoLk 15201 (LG 09746)	Early	Co 0238 GC	12.50	89.7	18.4	MR	NW
CoLk 15202 (LG 08420)	Early	LG 99001 GC	12.50	77.0	18.7	MR	NW
CoLk 15203 (LG 09743)	Early	Co 0238 GC	12.00	84.7	18.0	MR	NW
CoLk 15204 (LG 08869)	Early	CoPant 97222 GC	11.40	79.0	18.4	MR	NW
CoLk 15205 (LG 08422)	Early	CoS 96268 GC	9.80	75.7	19.0	MR	NW
CoLk 15206 (LG 07584)	Mid late	LG 95053 GC	15.00	110.7	17.3	MR	NW
CoLk 15207 (LG 09120)	Mid late	Co 88039 GC	13.50	96.7	18.4	MR	NW
CoLk 15208 (LG 07645)	Mid late	Bo 91 x CoH 56	11.80	83.3	18.2	MR	NW
CoLk 15209 (LG 07461)	Mid late	CoS 96268 GC	11.80	84.3	17.4	MR	NW
CoLk 15466 (MG 12001)	Early	CoS 8436 GC	10.80	89.6	17.5	MR	NC
CoLk 15467 (MG 10117)	Early	CoSe 95422 GC	10.26	84.5	17.6	MR	NC

Registration of breeding stocks

The planting material of sugarcane early variety CoLk 07201 has been submitted in active germplasm and index number SBI/2015/CoLk 07201/189 has been given. In addition, National Identity number IC 612238 has been given to this variety. Three high sugar parental clones sent to NHG in earlier years and subjected to extensive progeny tests exhibited good breeding value for early high sugar accumulation were found to be bonafide candidates for registration. Proposals for these sugarcane clones namely, LG 95123, LG 97050 and LG 01118 for registration with NBPGR were submitted.

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

The collection of 339 genotypes consisting of *Saccharum officinarum*, *S. barberi*, *S. sinense*, ISH clones, IkshuISH clones, LG selections, commercial hybrids, 25 somaclonal variants *etc.*, was maintained and the required material was supplied to various on-going projects of the Institute. It includes 162 commercial hybrids, 51 ISH and IkshuISH lines, 71 LG clones and 30 species level accessions.

A 'Varietal Cafeteria' comprising of 10 early and 12 mid-late maturing varieties recommended for Uttar Pradesh was planted in October, 2015 to provide an opportunity for farmers to select varieties of their choice.

Developing breeding stocks for high sugar in sugarcane

Since its inception in November 1993, the project targeted prebreeding of sugarcane for early sugar accumulation under subtropical growing conditions. The endeavour was to converge genes from diverse sources involving *S. officinarum* accessions, ISH clones and high sugar elite genotypes. For this purpose, recurrent selection programme was followed. During this period, the project enriched National Zone by CVRC) and registered one high sugar female breeding stock LG 95053 with NBPGR, New Delhi. Through progeny tests over the years, the parental stocks with high breeding value for early sugar accumulation have been identified. The salient research findings for the crop season 2015-16 are as follows:

Crossing programme at NHG, ICAR-Sugarcane Breeding Institute, Coimbatore: During the crossing season of 2015, high sugar parental clones developed under this project were involved in selfing, crossing and open-pollination in order to assess their breeding behaviour. The fluff was received for 5 Bi-parental crosses, 7 selfs and 16 General Collections (GCs).

Selection in C_1 seedling generation: The ratoon of seedlings raised from the fluff of 2013 crossing season was subjected to selection for hand refractometer brix in early December. The crosses giving high per cent of desirable selections and family mean for early brix were LG 01118 x CoLk 97147, LG 01118 x LG 05460, LG 05433 x LG 05460 and LG 05433 x LG 97022. Selfing of LG 05460 and LG 05480 also gave some very good selections (Table 1.2).

The second ratoon of seedlings of 2013 series was also observed for any high sugar genotypes with better ratooning ability and varietal merit. Four such promising selections were advanced. Similarly, another four genotypes were selected from the ratoon of C_1.

Field trials

Advance varietal trial: This trial was conducted in a randomized complete block design with 29 promising selections. These clones were given to the Division of Crop Protection for red rot, wilt and smut testing. Based on the crop performance and disease rating, three elite selections namely, LG 11427, LG 11434 and LG 11448 were given for further evaluation under the Station Trial (2016-17).

Early generation clonal evaluation: In fact, five

Table 1.2. Performance of C_0 seedlings (2014 series)

Mating	Number evaluated	Number selected	Per cent selection	Family mean brix	Selection mean brix
CoJ 641 Self	34	5	14.7	19.10	19.79
CoLk 97169 GC	4	3	75.0	22.10	21.80
LG 01118 x CoLk 97147	117	40	34.2	20.48	21.52
LG 01118 x LG 05460	73	30	41.1	20.60	21.30
LG 05433 x LG 05460	39	13	33.3	20.32	20.82
LG 05433 x LG 97022	143	52	36.4	19.84	21.04
LG 05460 Self	56	13	23.6	19.14	21.30
LG 05480 Self	83	14	16.9	18.74	20.67
Total	548	170	31.0	20.04	21.03

In 2016 spring season, an unreplicated trial with 54 selected clones was planted in an augmented design with four controls. Another spring experiment comprised of 170 C_1 selections along with appropriate checks for further evaluation.

Raising and transplanting of seedlings in field: Approximately 6,000 seedlings obtained through selfing, bi-parental crossing and open-pollination from 14 high sugar LG breeding stocks developed under this project, were raised and transferred to the field. Drip irrigation was installed in the field to ensure better seedling establishment and growth. This seedling population belongs to 2015 series.

High sugar selections sent to NHG: Three breeding stocks having high sugar *viz.*, LG 07502, LG 07518 (progenies of LG 01118 GC) and LG 07590 (Resulting from LG 95053 GC) were sent to the ICAR-Sugarcane Breeding Institute, Coimbatore for inclusion in the National Hybridization Garden.

Apart from these, two more clones *viz.*, LG 09487 and LG 08443 were earmarked as potential parents for high sugar, based on their performance in the Station Trial of 2015-16 as compared with the high sugar checks, CoJ 64 and Co 0238.

Diseases and insect-pests: This year, two viral diseases *viz.*, mosaic and yellow leaf remained the key diseases in C_0 population affecting a large number of seedlings. A few instances of wilt, smut, leaf scald and

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

Inclusion of genotypes in the Station Trial 2016-17

Three promising clones, *viz.*, LG 10803, LG 11819 (BO 91 × Co 62198) and LG 11835 (Co 86011 × ISH 147) having resistance to two pathotypes, *viz.*, CF08 and CF09 of red rot and sucrose % (>18.2%) were promoted to Station Trial 2016-17. These clones also recorded >88.3 t/ha cane yield.

Evaluation and selection of resistant clones to red rot in first and second clonal generation

A total of 42 clones from eleven different crosses namely Co 0238 × CoSe 92423 (4), BO 91 × CoS 90263 (5), CoLk 8102 × BO 91 (8), CoLk 8102 × CoH 15 (1), CoS 8436 × CoS 96260 (1), Co 98010 × Co 775 (1), Co 98008 × Co 775 (9), Co 86002 × ISH 147 (3), BO 91 × Co 62198 (7) and CoV 89101PC (3) were selected based on the yield attributes, reaction to red rot pathotypes CF08 and HR Brix%. These clones exhibited moderately resistant (30)/ moderately susceptible (12) reaction to red rot pathotype CF08. These clones recorded more than 18.3% HR brix with good agronomic performance. Variability for HR Brix ranged from 18.3% to 22.5% in selected clones. While, progenies of cross Co 98008 × Co 775 gave the highest mean value of HR brix % (>20.1). Clone LG I3822 (CoV 89101PC) gave the highest HR brix (22.5) followed by 22.4% HR Brix in Clone LG I3822 (Co 98008 × Co 775). These two clones

resistant (26)/ moderately susceptible (9) reaction to red rot pathotypes *Cf* 08. Seven clones, *viz.*, LG 12850 (Co 1148 × BO 91), LG 12853 (BO 91 GC), LG 12855 (ISH 11 GC), LG 12856 (ISH 11 GC), LG 12857 (ISH 11 GC) and LG 12859 (ISH 150 self) gave >18.3% sucrose and showed MR/MS reaction to red rot pathotypes CF08 and CF09. All these seven clones also showed good ratoonability with good phenotypic performance and advance to third clonal generation for further evaluation and selection for durable resistance, yield and quality attributes.

Evaluation of advance clones in plant and ratoon crops

A replicated trial with nine advanced clones was conducted along with three checks namely, Co 0238, CoJ 64 and CoS 767 to assess their yield and quality performance. Clones LG 10803, LG 11819, LG 11835, LG 10815, LG 10817, LG 08826 and LG 08869 showed moderately resistant (MR) reaction to two virulent pathotypes, *viz.*, CF08 and CF09 (Table 1.3). LG 11835 showed the highest cane yield (96.35 t/ha) followed by LG 11842 (88.92 t/ha), LG 11803 (84.55 t/ha) and LG 11819 (82.61 t/ha) over the best check Co 0238 (75.43 t/ha). These four clones recorded >17.6 % sucrose. Similar trend was recorded in ratoon crop with relatively low cane yield. However, LG 11835 (71.40 t/ha), LG 11821 (64.43 t/ha) and LG 11819 (63.75 t/ha) were found to be good ratooner. Three clones namely LG 10803, LG 11819 and LG 11835 exhibited moderately resistance reaction to red rot for two virulent pathotypes CF08 and CF09 over the years.

Development of top borer tolerant genetic stocks of sugarcane

Seedling evaluation: Four hundred seedlings derived from two intergeneric hybrids involving *Erianthus* sp. as one of parents (Awela-68 x IK 76-91 and LG 94184 x IK 76-81) and three general collections and one self of intergeneric hybrids were raised.

Five hundred thirty seven C_0 progenies derived from eight biparental crosses, six GCS and one self were evaluated for general vigour, top borer tolerance, HR brix and natural incidence of diseases and pests. Forty two were advanced for further evaluation.

Clonal evaluation: Out of 47 C_1 clones evaluated 13 advanced to C_2 stage. These clones were given for red rot evaluation. Out of 62 C_2 clones evaluated, 25 advanced to C_3 stage. The yield in selections ranged from 68-102 t/ha, sucrose in juice in January ranged from 17.27 to 19.02% with below 5% cumulative incidence of top borer infestation.

Genotype advanced to Station Trial: Four genotypes (LG 11632, LG 11645, LG 11650 and LG 11663) possessing superiority in yield, quality and resistance to red rot in addition to top borer tolerance were advanced to station trial. Five genetic stocks tolerant to top borer *viz.*, LG 07650, LG 07675, LG 07680, LG 07690 and LG 07692 were sent to National Hybridization Garden.

Biochemical evaluation: Hydroximic acids 2,4-dyhydroxy-1,4-benzoxazin-3-one (DIBOA) content was determined in different genotypes tolerant to top

Table 1.3. Performance of advance clones for yield and quality traits in plant crop during 2015-16

Clone	Parentage	NMC (000/ha)	Yield (t/ha)	Sucrose (%)	CCS (t/ha)	Reaction to red rot pathotype	
						CF08	CF09
LG 10801	BO 91 × Co 62198	129.08	77.51	19.82	10.57	MS	MR
LG 10803	BO 91 × Co 62198	135.65	84.55	19.11	11.12	MR	MR
LG 10805	BO 91 × Co 62198	121.40	63.57	18.01	7.82	MS	MR
LG 10807	BO 91 × Co 62198	121.33	70.78	17.30	8.34	MR	MR
LG 11819	BO 91 × Co 62198	140.02	82.61	19.30	10.98	MR	MR
LG 11821	BO 91 × Co 62198	135.88	79.27	18.83	10.22	MR	MR
LG 11829	Co 1158 × BO 91	119.93	72.32	16.87	8.29	MS	MR
LG 11835	Co 86011 × ISH 147	145.19	96.35	19.36	12.79	MR	MR

borer, it ranged from 10.08 to 19.22 mmol/kg fwt, while sensitive ones exhibited below 10.08 mmol/kg fwt DIBOA content.

Development of sugarcane varieties for sub-tropics

Hybridization and growing of seedlings: Twenty eight bi-parental crosses and 28 GCs were attempted at NHG, ICAR-SBI, Coimbatore during October-November, 2015. In addition, fluff of six Zonal Crosses and 08 PCs comprising of biparental and poly-crosses were received for evaluation under this project. The fluff received for these crosses will be sown in the glass house to raise seedling population. The seedling will be transplanted during July/August, 2016. Seedlings grown in the glass house from the crosses of 2014 crossing year transplanted in the field. A total of 7,934 seedlings are growing well in the field.

Evaluation of sugarcane crosses and clones: A total of 293 clones from 45 crosses (2013 crossing series) were selected and planted in the field for multiplication and evaluation along with standards (CoJ 64, Co 0238, CoS 767 and CoPant 97222) during autumn season. Selection was done considering HR Brix % value more than 18 during October. General growth, stalk diameter green cane top and other morphological features was also taken into consideration for selection.

Evaluation of promising C_3 Clones: Forty five C_3 (third clonal generation) cane along with two standards (CoJ 64 and Co 0238) were planted with an aim for their multiplication and evaluation. In addition, along with these clones, six C_4 clones were also evaluated. Based on quality and other parameters, 18 clones were advanced for multiplication and further evaluation with four standards.

Multiplication of promising clones: Eighteen sugarcane clones (Table 1.4) possessing quality traits suitable for further evaluation under early and mid-late group were multiplied and evaluated for juice quality from November to February. Some of the better performing clones having good juice quality were proposed for further evaluation in Station Trial of Crop Improvement Division.

Table 1.4. Performance of some promising clones under multiplication with special reference to sucrose content

Genotype	Parentage	Sucrose (%)			
		November	December	January	February
LG 09741	SP-80-185 GC	14.7	14.3	17.0	18.5
LG 09738	SP-80-185 GC	17.4	15.6	17.7	18.6
LG 11701	CoS 88216 GC	14.2	13.6	15.5	17.8
LG 11703	Co 89029 GC	15.1	13.7	17.6	18.1
LG 08749	Co 98010 × CoPant 97222	16.3	17.9	17.9	16.5
LG 11702	Co 0239 GC	15.4	17.9	16.8	16.6
LG 08758	CoJ 72 × CoSe 92423	15.2	15.6	16.0	14.6
LG 08776	CoH 56 GC	16.3	16.4	17.9	17.5
LG 10717	CoJ 83 × CoPant 97222	14.1	12.6	14.7	16.2
LG 09039	81 V 48 × CoH 70	16.2	15.5	19.2	19.7
LG 09760	CoS 8436 GC	13.4	15.1	17.1	16.5
LG 07096	CoJ 99192 × Co 86002	16.7	17.9	17.8	18.0
LG 09707	PO 91 × Co 86002	14.5	16.8	16.9	18.6

Evaluation of advanced PVT clones: An experiment was conducted with 18 advanced clones and two early standards CoJ 64 and Co 0238 (Table 1.5, 1.6) in three replications. CCS (t/ha) was significantly higher for LG 11001 and LG 11705 over the best standard Co 0238. Three clones LG 09120, LG 11705 and LG 11001 recorded higher cane yield (t/ha) over both the standards. Sucrose % at 8 month was higher in LG 09743 and LG 11212 over the best standard CoJ 64 and at 10 month, LG 11212, LG 09120, and LG 09743 recorded higher sucrose % value over the standards.

Seed multiplication (Early): The planting material of eight genotypes, *viz.*, Co 14034, CoLk 14201, CoLk 14202, CoPant 14221, CoPant 14222, CoPb 14181, CoPb 14182 and CoPb 14211 was multiplied for next year's IVT trial. The planting material of 2013 series for AICRP(S) was also brought from ICAR-SBI RC, Karnal and planted at ICAR-IISR Research Farm for multiplication. The planting material of nine clones from ICAR-IISR, Lucknow for North West Zone accepted for evaluation was supplied to ICAR-SBI, RC, Karnal for further multiplication and distribution to other centres of North West Zone of AICRP(S). Co 13033 was highly susceptible to wilt. This entry was not considered for planting as a part of trial as planting material could not be supplied by proposing centre. The genotype, CoPb 13181 was also recorded as moderately susceptible to wilt disease.

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

Evaluation of elite clones: Ten promising sugarcane genotypes were evaluated for their growth performance and quality parameters. Out of these, four elite clones, MG 10007, MG 12001, MG 10117 and MG 10090 were found to be superior to the best standards CoSe 95422 and CoP 9301. In addition, 23

Table 1.5. Performance of advanced clones for commercial cane sugar and important yield attributing traits

Genotype	Parentage	CCS (t/ha) January	Cane yield (t/ha)	NMC (000/ ha)	Cane length (m)	Cane diameter (cm)	Single cane weight (kg)
LG 11212	CoJ 99192 PC	6.4	51.3	82	2.3	2.3	0.6
LG 09019	CoS 8436 PC	5.2	50.4	72	1.7	2.3	0.7
LG 11121	CoSe 92423 PC	6.4	64.6	72	2.2	2.2	0.9
LG 09120	Co 88039 GC	9.9	77.9	94	1.8	2.3	0.8
LG 09119	Co 88039 GC	7.3	64.6	84	1.9	2.4	0.8
LG 10006	CoH 76 × Co 62198	7.8	60.3	86	2.0	2.2	0.7
LG 11704	LG 02057 GC	7.6	63.5	91	2.0	2.3	0.7
LG 11167	CoS 8436 PC	5.7	49.9	79	1.8	2.0	0.6
LG 11705	Co 98014 GC	10.7	90.2	108	2.0	2.2	0.8
LG 11706	BO 146 GC	7.4	60.6	73	1.9	2.3	0.8
LG 11001	87A 298 × CoSe 92423	11.3	90.8	94	1.8	2.7	1.0
LG 11158	CoS 8436 PC	5.5	52.0	65	1.7	2.6	0.8
LG 11166	CoS 8436 PC	6.2	53.0	64	1.9	2.4	0.8
LG 09743	Co 0238 GC	8.7	64.2	80	2.1	2.4	0.8
LG 10726	CoS 8436 × CoSe 92423	5.8	49.5	74	1.8	2.2	0.7
LG 11707	CoLk 8102 GC	7.5	63.6	87	1.9	2.2	0.7
LG 11708	CoSe 95422 GC	7.1	63.5	87	2.1	2.5	0.7
LG 10723	CoS 8436 × CoSe 92423	5.8	46.7	67	2.0	2.3	0.7
Standards							
CoJ 64		6.2	50.0	83	1.8	2.3	0.6
Co 0238		8.2	65.0	81	2.1	2.7	0.8
CD (0.05)	-	1.8	12.3	11.90	0.2	0.2	0.1
CV(%)	-	14.8	12.0	8.86	7.2	5.9	8.1

Table 1.6. Performance of advanced clones for yield and juice quality characters

Genotype	Sucrose (%)			Purity (%)			CCS (%)		
	November	December	January	November	December	January	November	December	January
LG 11212	16.53	18.87	18.13	85.37	91.13	87.90	11.23	13.23	12.53
LG 09019	12.20	15.23	15.20	77.27	86.90	85.70	7.87	10.47	10.37
LG 11121	13.97	13.67	14.70	79.23	82.23	84.43	9.10	9.10	9.93
LG 09120	15.67	17.33	18.40	83.73	87.80	88.40	10.57	11.97	12.70
LG 09119	16.00	15.20	16.40	85.73	87.13	86.40	10.90	10.47	11.27
LG 10006	12.07	15.97	18.60	77.37	89.40	88.43	7.77	11.07	12.83
LG 11704	15.90	17.20	17.43	84.67	87.50	87.33	10.77	11.83	12.00
LG 11167	15.90	15.50	16.47	85.87	85.20	85.80	10.83	10.53	11.23
LG 11705	13.30	15.17	17.23	77.53	82.80	87.80	8.57	10.13	11.87
LG 11706	14.53	15.83	17.50	80.10	86.47	88.90	9.57	10.83	12.13
LG 11001	15.10	17.13	17.90	82.03	88.90	88.93	10.07	11.87	12.40
LG 11158	12.60	14.80	15.60	77.17	86.70	85.63	8.07	10.13	10.63
LG 11166	13.60	15.27	17.07	83.30	87.73	87.77	9.10	10.53	11.73
LG 09743	18.07	18.30	19.30	87.37	89.30	89.43	12.43	12.73	13.43
LG 10726	15.87	16.10	16.93	84.60	87.10	86.77	10.73	11.07	11.57
LG 11707	12.37	15.97	17.07	75.83	86.90	87.20	7.87	10.93	11.77
LG 11708	12.00	14.67	16.20	77.60	87.43	86.97	7.77	10.10	11.10
LG 10723	14.47	17.17	18.13	80.70	88.20	89.03	9.57	11.87	12.63
Standards									
CoJ 64	16.23	17.80	17.83	84.20	88.67	89.00	11.00	12.33	12.37
Co 0238	15.20	16.23	18.23	84.13	87.97	88.10	10.23	11.20	12.60
CD (0.05)	1.67	1.36	1.24	5.07	4.73	2.88	1.39	1.16	0.98
CV(%)	6.91	5.06	4.33	3.75	3.27	1.99	8.64	6.27	5.01

promising sugarcane clones (LG 07757, LG 07776, LG 08749, LG 08758, LG 08776, LG 09039, LG 09707, LG 09738, LG 09741, LG 09743, LG 09746, LG 09760, LG 10717, LG 10723, LG 10726, LG 11701, LG 11702, LG 11703, LG 11704, LG 11705, LG 11706, LG 11707 and LG 11708) selected under Lucknow conditions were sent to ICAR-IISR RC, Motipur for their testing in target environments.

Hybridization and seedling raising: Approximately 5,912 seedlings, raised from 24 bi-parental sugarcane crosses attempted during crossing season 2014, were transplanted at ICAR-IISR RC, Motipur for their evaluation under target condition (Table 1.7). Eight bi-parental crosses were attempted at the National Hybridization Garden, ICAR-Sugarcane Breeding Institute, Coimbatore during the 2015 crossing season. In addition, 16 zonal crosses and 8 poly crosses for North Central Zone were also attempted during the season. Fluff of all the station crosses, zonal crosses, poly crosses and 20 GCs was received and will be sown to raise good number of seedlings.

Evaluation of early maturing sugarcane clones under North West Zone of AICRP (S)

Initial Varietal Trial (Early): Ten entries, *viz.*, Co 12026, Co 12027, CoH 12261, CoLk 12201, CoLk 12202, CoLk 12203, CoLk 12204, CoPant 12221, CoPant 12222 and CoS 12231 were evaluated along with CoJ 64 and Co 0238 as standards. The clones CoS 12231 and Co 12026 were recorded as susceptible to wilt disease. The highest CCS (t/ha) was recorded in CoLk 12201 followed by CoLk Co 0238 (standard) and CoLk 12203. The highest sucrose % at 10 month was recorded in

Table 1.7. Cross-wise seedlings raised and transplanted at ICAR-IISR Regional Centre, Motipur

Cross	No. of seedlings	Cross	No. of seedlings
Co 1158 × Co 62198	536	CoSe 95422 × Co 62198	464
CoS 8436 × Co 0233	224	BO 91 × Co 62198	192
CoLk 7901 × ISH 176	224	LG 06810 × CoSe 92423	64
CoSe 95422 × CoS 8436	840	CoLk 94184 × BO 91	72
LG 05460 × CoSe 92423	568	Co 0233 × CoS 8436	32
CoP 06436 × BO 130	232	CoLk 8102 × Co 62198	24
CoS 8436 × Co 1148	288	CoS 96268 × ISH 287	16
BO 91 × CoH 15	1080	BO 92 × Co 86249	16
UP 9530 × CoP 9301	144	Co 98014 × Co 86249	8
CoJ 80 × Co 86011	48	CoLk 8102 × BO 130	8
BO 97 × BO 32	184	CoSe 96436 × Co 0233	216
BO 97 × Co 775	176	CoP 06436 × CoPant 97222	256

CoLk 12201. The overall performance of trial was excellent.

Advanced Varietal Trial (Early) I Plant: Four genotypes, *viz.*, CoLk 11201, CoLk 11202, CoLk 11203 and CoH 11262 along with two standards Co 0238 and CoJ 64 were evaluated for yield and quality parameters. The genotype, CoH 11262 was recorded as susceptible to wilt disease at late stage of crop season. The highest CCS (t/ha) was recorded in CoLk 11203 followed by CoLk 11201 but none of the entry was found superior to the best check Co 0238.

Advanced Varietal Trial (Early) II plant: A trial with three genotypes, *viz.*, Co 10035, CoH 10261 and CoS 10231 along with two standard varieties, *viz.*, CoJ 64 and CoPant 84211 was conducted. Observations on yield and quality parameters were recorded as per technical programme. Almost all the entries recorded moderate susceptibility to wilt.

Evaluation of mid late maturing sugarcane clones under North West Zone of AICRP (S)

Initial Varietal Trial (Mid late): Fifteen sugarcane clones, *viz.*, Co 12028, Co 12029, CoH 12262, CoH 12263, CoLk 12205, CoLk 12206, CoPant 12223, CoPant 12224, CoPant 12225, CoPant 12226, CoPb 12181, CoPb 12182, CoPb 12211, CoPb 12212 and CoS 12232 along with three standards CoS 767, CoS 8436 and CoPant 97222 were evaluated for yield and quality parameters. The genotype CoPb 12182 recorded the highest cane yield (92.7 t/ha) followed by CoLk 12205 (86.5 t/ha) and CoPant 12226 (82.6 t/ha). The genotype CoPb 12182 showed the highest CCS yield (11.24 t/ha) followed by CoPant 12226 (10.69 t/ha) and CoLk 12205 (9.86 t/ha). Among the test genotypes, CoPant 12226 recorded the highest sucrose percentage at harvest (18.5%) followed by CoH 12262 (18.3%) and Co 12028 (18.2%). Among the standard varieties, CoPant 97222 recorded the highest CCS yield (10.96 t/ha) followed by CoS 767 and CoS 8436.

Advanced Varietal Trial (Mid late) I Plant: A trial comprising of six genotypes, *viz.*, Co 11027, CoH 11263, CoLk 11204, CoLk 11206, CoPb 11214 and CoS 11232 along with three standard varieties CoS 767, CoS 8436 and CoPant 97222, was conducted. The genotype CoS 11232 was completely damaged due to wilt, therefore, it was not possible to include it in the data analysis and interpretation of results. CoLk 11206 recorded the highest cane yield (112.9 t/ha) which was significantly superior to the best check. The genotype CoH 11263 exhibited the highest sucrose % at harvest (18.7 %) followed by CoLk 11204 (18.1%) and CoLk 11206 (18.0 %). Among the standard varieties, CoPant 97222 was found to be the best for cane yield (87.9 t/ha) as well as CCS yield (11.47 t/ha).

Advanced Varietal Trial (Mid late) II Plant: A trial comprising of five sugarcane clones, *viz.*, Co 10036, CoH 10262, CoPant 10221, CoPb 10181 and CoPb 10182 along with three standard varieties *viz.*, CoS 767, CoS 8436 and CoPant 97222 was conducted. Various observations on yield and quality parameters were recorded. Genotype CoPant 10221 recorded the highest cane yield (79.3 t/ha) followed by CoPb 10182 (73.9 t/ha) and Co 10036 (56.6 t/ha). Also, CoPant 10221 had shown the highest CCS yield (10.09 t/ha) followed by CoPb 10182 (9.20 t/ha) and CoH 10262 (7.10 t/ha). The genotype CoPb 10181 showed the highest sucrose percentage at harvest (19.0%) followed by CoH 10262 (18.3%). Among the

standards, CoS 767 was the best check for cane yield (84.2 t/ha) and CoPant 97222 was the best for CCS yield (11.47 t/ha).

Advanced Varietal Trial (Midlate) Ratoon: Five genotypes, *viz.*, Co 10036, CoH 10262, CoPant 10221, CoPb 10181 and CoPb 10182 along with three standard varieties, *viz.*, CoS 767, CoS 8436 and CoPant 97222 were also evaluated for their ratooning ability. In general, ratoon crop was average due to poor sprouting at the time of initiation. It may be because of severe infestation of *Pyrilla* at the later stages of the previous plant crop and it was heavily damaged. The genotype CoPb 10182 recorded the highest cane yield (59.4 t/ha) and CCS yield (5.92 t/ha). Among the standard varieties, CoS 767 and CoPant 97222 both were at par for cane yield as well as CCS yield.

Seed multiplication: The seed of thirteen genotypes, *viz.*, Co 13035, Co 13036, CoH 13261, CoH 13262, CoH 13263, CoLk 13204, CoLk 13205, CoPant 13223, CoPant 13224, CoPb 13182, CoPb 13183, CoS 13232 and CoS 13233 was multiplied for next year's IVT trial.

Evaluation of early maturing sugarcane clones under North Central and North Eastern Zone of AICRP (S)

Five genotypes CoLk 12207, CoLk 12208, CoP 12436, CoP 12437 and CoSe 12451 along with two standards CoSe 95422 and BO 130 were evaluated in Initial Varietal Trial (IVT) early group. CoLk 12208 exhibited superiority in yield.

Four genotypes *viz.*, CoP 11432, CoP 11437, CoP 11438 and CoSe 11451 along with two standards were evaluated under Advanced Varietal Trial (AVT) early. CoP 11436 was found superior in cane yield and sugar yield.

Evaluation of mid late maturing sugarcane clones under North Central and North Eastern Zone of AICRP (S)

Six genotypes along with three standards were evaluated in Initial Varietal Trial (IVT) mid late. CoSe 12453 and CoLk 12209 showed the best cane and sugar yield.

Four genotypes along with there standards were evaluated in Advanced Varietal Trial (AVT) mid late found superior in yield and quality.

Genetic improvement in elite clones of sugarcane evaluated under All India Coordinated Research Project on Sugarcane

Genetic improvement in economic yield is a key of success in a breeding programme of any crop. For effective monitoring of the programme at national or zonal level, it needs to measure in quantitative terms at regular intervals. One of the major coordinated efforts right from the inception of the AICRP on Sugarcane has been the Zonal Varietal Trials which are conducted under the Crop Improvement discipline at about 40 research stations located in five sugarcane agro-climatic zones across the country. Under zonal varietal trial, elite clones are being evaluated since 1998-99 in all the five sugarcane agro-climatic zones. It is necessary to assess the impact of breeding programme on genetic improvement of sugarcane over the years. In this study, attempt has been made to assess the genetic improvement in elite clones of sugarcane evaluated in zonal varietal trials conducted from 1989 to 2015.

Database on evaluation of sugarcane clones on zonal basis

Long term database of sugarcane cane yield recorded in zonal varietal trials conducted in five zones of the country was developed and analyzed for genetic improvement in cane yield over the years commencing from 1989 to 2015. The trials were conducted under same set of agro-ecological conditions in a zone with separate trials of early and mid-late maturing varieties. In one zone, at all the locations, the trial was conducted with same set of varieties, package of practices, same time of planting/harvesting, seed rate, plot size, number of replications, and time of harvesting and with same system of data recording. This is being done to maintain the uniformity of the trials in a zone which helps in true assessment of the genetic expression of sugarcane clones.

Genetic improvement in sugarcane during 1991 to 2015

During 1989 to 2015, a total of 526 trials were conducted in five zones with different agro-ecological

all the zones, 256 (49%) trials were conducted in early maturity group and 270 (51%) in mid-late maturity group (Table 1.8).

A total of 2,311 elite clones were evaluated during 1989 to 2015. The highest number (39.81%) of clones was tested in peninsular zone followed by 26.18% in the North West zone, 19.86% in the North Central Zone, 10.30% in the East Coast Zone and minimum (3.85%) in the North Eastern Zone (3.85%). Out of 2311 clones, a total of 436 (18.87%) early maturing clones were evaluated in Advanced Varietal Trial (AVT) and 559 (24.19%) in Initial Varietal Trial (IVT). Under mid-late maturity group, a total of 524 (22.67%) clones were evaluated and 792 (34.27%) in IVT (Table 1.9).

The overall rate of genetic improvement in cane yield was progressive in all the four zones during 1991 to 2015, *i.e.*, 3.76% during 1991 to 2000, 16.33% during 2001 to 2010 and 20.41% during 2011 to 2015 over the base period 1989 - 1990. Similar progressive trend was observed in each zone also. The highest genetic improvement (48.74%) was recorded in the North West Zone during the period 2011 to 2015 followed by (38.70%) during 2001 to 2010 and 25.42% during the period 1991 to 2000 over the base period 1989 to 1990. The cane yield increased from 51.50 t/ha (1989 to 1990) to 76.60 t/ha (2011 to 2015). Similar trend was also observed in East Coast zone. The highest genetic improvement (43.76%) was recorded in the East Coast zone during the period 2011 to 2015 followed by (30.98%) during 2001 to 2010 and 24.87% during the period 1991 to 2000 over the base period 1989 to 1990. The cane yield increased from 75.52 t/ha (1989 to 1990) to 108.60 t/ha (2011 to 2015). The lowest (negative) genetic improvement was observed in the North Central & the North Eastern Zones during the period 1991 to 2000 (-12.61%), followed by the period 2001 to 2010 (-2.59%) and (6.76%) during 2011 to 2015, but the trend of genetic improvement was incremental during 2011-2015. The average cane yield increased from 65.52 t/ha during 1989 to 1990 to 69.95 t/ha during 2011 to 2015. In Peninsular Zone, the pace of genetic improvement was slow in comparison to the North West and East Coast Zones. The highest (14.64%) genetic improvement was noted during the period 2001 to 2010 followed by 12.72% during 2011 to 2015 and negative improvement (-1.18)% during 1991 to 2000 over the base period 1989 to 1990. The cane yield

Table 1.8. Number of sugarcane trials conducted under All India Coordinated Research Project on Sugarcane during 1989-2015

Zone	Early	Mid-late	Total
Peninsular Zone	71	89	160 (30.42)
East Coast Zone	61	44	105 (19.96)
North West Zone	64	71	135 (25.67)
North Central and North	60	66	126 (23.96)
	256 (48.67)	270 (51.33)	526 (100)

Table 1.9. Number of entries tested in Initial Varietal Trial (IVT) and Advance Varietal Trial (AVT) under All India Coordinated Research Project on Sugarcane during 1989 - 2015

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

Figure in parenthesis is per cent increase over total

Table 1.10. Genetic improvement in sugarcane yield (t/ha) through All India Coordinated Research Project on Sugarcane

Year	Peninsular Zone	East Coast Zone	North West Zone	North Central and North Eastern Zone	Overall
1989-1990	87.68	75.52	51.50	65.42	72.70
1991-2000	86.65 (-1.18)	94.33 (24.91)	64.59 (25.42)	57.26 (-12.61)	75.43 (3.76)
2001-2010	100.51 (14.64)	98.94 (31.02)	71.43 (38.70)	63.82 (-2.59)	84.58 (16.33)
2011-2015	98.83 (12.72)	108.60 (43.80)	76.60 (48.74)	69.95 (6.76)	87.54 (20.41)

Figure in parenthesis is per cent increase over average cane yield of 1989 to 1990

breeding programme in all the five zones of AICRP on Sugarcane. Under All India Coordinated Research Project (AICRP) on Sugarcane, breeding programme in the country has shown remarkable improvement in about three decades (1989 - 2015). So far, a total of 114 varieties have been identified in AICRP on Sugarcane and of these, 52 varieties have been released and notified for cultivation in different parts of the country. Due to improved varieties for cultivation in the country, its impact has shown excess sugar production in the country during last five consecutive years (2010-11 to 2014-15). Further analysis and reason of negative impact in few block years is in progress and work has also been taken up to analyse the data of other traits of sugarcane in similar lines.

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

To understand numerical chromosomal variation in sugarcane and to decipher the contribution of species-specific chromosomes in elite genotypes, the variation in chromosome number among the progeny clones *vis-à-vis* parent was studied in the sugarcane variety CoLk 8102 and the clonal generation of a cross population CoLk 8102 GC. For chromosome variability studies in parent and progeny population, pre-treated and fixed samples of both were scored for chromosome numbers from somatic chromosome squash preparations. The average chromosome numbers per cell ranged from 98-110 in CoLk 8102, whereas, the modal chromosome number was 2n=ca in 108. In the clonal progeny population, the mitotic chromosome numbers ranged from 90-112 per cell. Optimization of probe preparation and hybridization was continued from previous year for *in situ* hybridization studies but no confirmatory results were obtained.

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

Isolation of disease resistance gene analogues (RGAs) using the conserved motifs of the resistance genes was continued using homology-based PCR to *viz.*, BO 91 and one red rot susceptible genotype *viz.* CoJ 64. PCR results revealed amplification with some of the primer combinations. PCR products showing specific fragments were purified and sequenced. The sequences were analyzed computationally to reveal ten putative RGAs. The length of RGA fragments varied from 400 to 800 bp and they were found matching to *Pto* gene of kinase domain and *Xa21* and *Cf9* genes of leucine-rich repeat resistance protein-like gene sequences.

Standardization and profiling of small RNA transcriptome of sugarcane under abiotic stress conditions

An exploratory study was done to decipher the role of small RNA transcriptome in sugarcane by identifying various small RNAs in response to abiotic stress conditions (waterlogging or salt or low temperature). Total RNA was extracted by trizol method from leaf tissue with or without abiotic stress treatment at different time intervals and small RNA libraries were constructed followed by deep sequencing. Total of 114 miRNAs consisting of 56 novel miRNAs were identified in control. More than 80 total miRNA consisting of 28, 41 and 34 novel miRNA were identified in salt, waterlogging and cold stress treatments, respectively. A total of 2051 and 3354 target genes were predicted for known and novel miRNAs, respectively. The results provided initial clue to further study molecular mechanisms on abiotic stresses regulation in sugarcane.

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

Identification of small RNAs from sugarcane is a critical step towards understanding small RNA-guided gene regulation, especially when there is no information available regarding genes controlling red rot resistance in sugarcane. This project has been initiated to unravel the conserved and altered miRNA profile in response to red rot disease. To start with,

Mapping of loci linked to sugar content in sugarcane

Out of a subset of 240 clones phenotyped from a population of CoLk 7901 self, approximately 47% of the clones exhibited mean Pol% juice values 14-17% during the peak period (January). 9% were of low sugar content with mean Pol% juice values 7-12%. 10% of the population exhibited 9-12% Pol% juice. Eleven genotypes had a mean pol% juice value ranging from 18.9-20.3% during January. A few of the clones showed good vigour with green leaves, no lodging and moderate pol% juice values. The genotypes E-39, E-38, E-116. E-117, E-141, E-152 and E-312 had a single cane weight value 0.7-0.8 kg. The mean pol% juice values were moderate (14-17%). These may be probable candidates for use in improvement efforts for biomass for development of energy canes. Genotyping studies in the mapping population was carried out using approximately 20 primer pairs and is being continued.

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

Red rot is a threatening disease of sugarcane and under epiphytotic conditions, it has potential to damage the crop entirely. The complexities of sugarcane genome impede the efforts to genetically manipulate sugarcane for red rot resistance using traditional breeding approaches. However, considerable efforts have been made in recent years to develop different types of molecular markers in order to identify the genomic regions possibly involved in expression of different traits including red rot resistance. In a recent study, we have successfully identified Marker Trait Association (MTAs) for red rot resistance using SSR markers in sugarcane genotypes. Further, in absence of sugarcane genome sequence, we harnessed the co-linearity between sugarcane and sorghum genome, and identified the genes in vicinity of MTAs linked to red rot resistance. The amino acid sequences predicted from gene models of genes located in the region flanking MTAs for red rot sugarcane genotypes with contrasting reaction to red rot, *viz.*, BO 91, SES 594, CoLk 94184, CoS 767, CoJ 64 and Co 1148. Among the selected genotypes, three were resistant (BO 91, SES 594, CoLk 94184) and three were susceptible (CoS 767, CoJ 64, CO 1148) for red rot reaction. The genomic DNA from all the six genotypes were amplified using all the 20 primers (CGP1-CGP20). Out of twenty, ten primer pairs gave successful amplification in all the genotypes used. Promisingly, one primer pair has given a PCR product ~800 bp in all the resistance genotypes but not in susceptible genotypes. This could be possibly gene involved in red rot resistance. Further confirmation through sequencing is in progress. Besides above, three crosses, *viz.*, BO 91 × Co 62198, BO 91 × ISH 150 and BO 91 × ISH 147 were made for development of mapping populations.

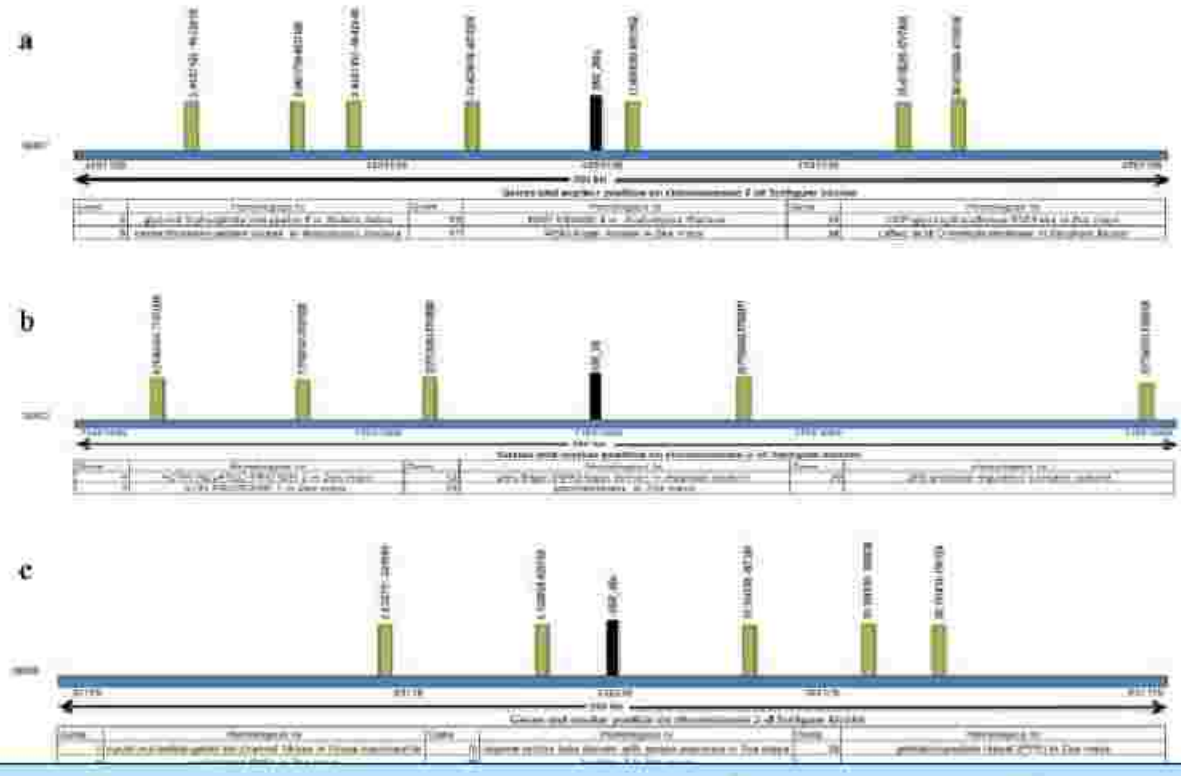
Identification of putative candidate genes for red rot resistance in sugarcane using LD-based association mapping

Red rot is a serious disease of sugarcane caused by the fungus *Colletotrichum falcatum* that has a colossal damage potential. The fungus, prevalent mainly in the Indian sub-continent, keeps on producing new pathogenic strains leading to breakdown of resistance in newly released varieties and hence, the deployment of linked markers for marker-assisted selection for resistance to this disease can fine tune the breeding programmes. This study based on a panel of 119 sugarcane genotypes fingerprinted for 944 SSR alleles was undertaken with an aim to identify marker-trait associations (MTAs) for resistance to red rot. Mixed-linear model containing population structure and kinship as co-factor detected four MTAs that were able to explain 10–16% of the trait variation, individually (Table 1.11). Among the 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 Cf01) aligned on sorghum chromosome 7

Table 1.11. Significant marker-trait associations (MTAs) identified for resistance to three races of red rot pathogen *C.falcatum*

Red rot pathotype	Marker	GLM		MLM	
		-log P value	Variation explained in the trait	-log P value	Variation explained in the trait
Cf01	IISR_298a_140	4.55**	0.168	4.12*	0.166
	IISR_256_240	4.12*	0.118	3.97*	0.107
	IISR_90_360	3.95*	0.101	-	-
Cf08	IISR_198_170	4.00*	0.105	-	-
Cf09	IISR_46b_170	4.85**	0.174	4.07*	0.145
	IISR_148_200	3.92*	0.118	-	-
	SCB10_410	4.25**	0.133	-	-
	EST A69_400	3.85*	0.113	-	-
	IISR_137_240	-	-	3.95*	0.117

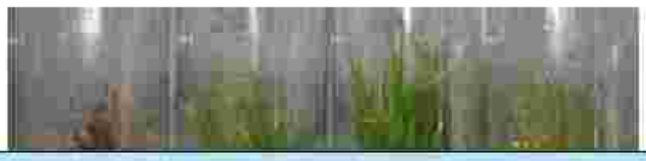
GLM = general linear model; MLM = mixed linear model; **-log P value that satisfy Bonferroni correction factor (cut-off 4.17); *-log P value that satisfy Benjamini Hochberg false discovery rate



for marker IISR_137_240. Several genes encoding important plant defence related proteins, *viz.*, cytochrome P450, Glycerol-3-phosphate transporter-1, MAP Kinase-4, Serine/threonine-protein kinase, Ring-finger domain protein and others were localized to the vicinity of these MTAs. These positional candidate genes are worth of further investigation and possibly these could contribute directly to red rot resistance, and may find a potential application in marker-assisted sugarcane breeding.

Production of disease-free and genetically pure seedcane through micropropagation

Sugarcane is traditionally propagated through vegetative means, thus application of micropropagation technique assumes significance for rapid multiplication of new varieties with premium traits and production of disease-free genetically uniform seedcane. This year, rapid *in vitro* clonal propagation of sugarcane genotypes, CoLk 07201, CoLk 9709, and Co 05011 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) + 4.6 µM kinetin (Kin) + 3% sucrose. The maximum shoot proliferation per explant with 100% shoot regeneration frequency was obtained on MS medium supplemented with 2.22 µM BA + 2.3 µM Kin + 26.8 µM naphthalene acetic acid (NAA) + 3% sucrose (Fig. 1.2). Vigorous rooting was obtained on MS medium containing 26.8 µM NAA and 3% 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 20000 plantlets of varieties CoLk 07201, CoLk 9709 and CoLk 05011 were transferred to field. The sugarcane thus obtained from such micropropagated plantlets after one cycle of multiplication in the field could be distributed as genetically uniform seed cane.



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

Slow-growth refers to restricting growth and morphogenesis *in vitro* by decreased temperature, nutrient and/or sucrose availability, alteration of photoperiod conditions, presence or absence of growth regulators and addition of osmotic substances. This in turn, minimizes the need of frequent sub-culturing, allows reduced space requirements and consequently labour cost for the maintenance of germplasm collections. Consequently, *in vitro* preservation of sugarcane germplasm using slow-growth culture technique is being explored. The shoot tip explants of sugarcane genotype Khakai were established under *in vitro* conditions and multiplication of established cultures was done on MS medium supplemented with 2.22 µM BA, 0.5 µM Kinetin, 0.5 µM GA_3 so as to obtain stock cultures for various treatments for slow growth. Treatment of cultures with high osmoticum (0-10% sucrose in the medium; Fig. 1.2), two temperature regime (8°C and 25°C) and semi-solid and liquid medium is under progress.

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

An Accredited Test Laboratory (ATL) for genetic fidelity and virus indexing of tissue culture raised plants has been established in July 2015 at ICAR-IISR, Lucknow with the financial support of ₹ 65.0 lakh from Department of Biotechnology, New Delhi under National Certification System of Tissue Culture-raised Plants (NCS-TCP). During the period of July 2015 to March 2016, a total of 330 samples of sugarcane and banana tissue culture from DBT recognized tissue culture production facilities located in the States of Uttar Pradesh, Haryana, Chhattisgarh, Gujarat and Madhya Pradesh were tested for genetic fidelity and virus indexing for batch certification. This amounts to certification of 3.3 lakh tissue cultured plants. Similarly, a total of 280 samples of mother stock of

genotypes with contrasting sucrose level was carried out in order to generate a segregating population (F_1), which could be used for linkage mapping in order to identify QTLs related to sucrose and other agronomically important traits. A total of 492 seedlings were obtained from the cross MS68/47 (low sucrose) × CoV 92102 (high sucrose) and transferred individually to polythene bags 25 days after germination for further growth. Finally, a total of 262 healthy seedlings were established in the field.

In order to identify authentic F_1s, markers were screened that are specific to the male parent and inherited in the F_1 plants. From the highly informative EST-SSR markers developed in our lab and other published literature, a total of 5 EST SSR markers were selected that were male parent specific (Fig. 1.3). These markers have been used for selecting true F_1s to represent the mapping population. The genomic DNA of the true hybrids along with the two parental lines will be used for genotyping by sequencing (GBS) analysis. The data on number of primary tillers was recorded in the mapping population and sufficient degree of segregation was present (Fig. 1.4).

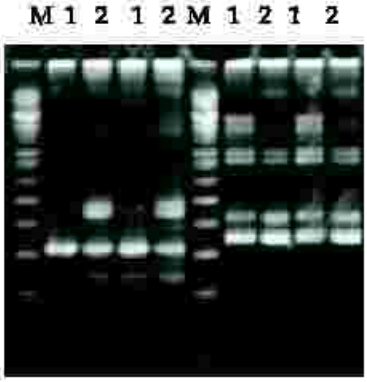
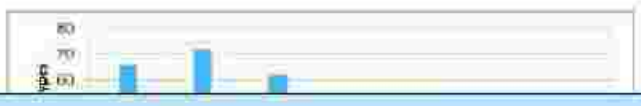


Fig. 1.3. Identification of male parent-specific amplification product between the two parental lines based on EST SSR primers IISR_139 and SCA04. 1: Female parent; 2: Male parent; M: DNA size marker. The arrows indicate the products specific to the male parent



Phenotyping is in process for a number of other agronomically important traits like sucrose content, number of millable canes, cane weight, cane diameter, cane length, *etc.* The mapping population will be measured for sucrose Brix content in October 2016.

Breeder seed production at ICAR-IISR-RC, Motipur, Bihar

The 24,000 q of breeder seed of six varieties, *viz.*, CoLk 94184, Co 0232, CoP 9301, Co 0238, Co 0118 and BO 153 in 46 ha at Motipur, Harinagar, Hasanpur and Narakatiaganj under breeder seed production sponsored by Sugarcane Industries Department, Government of Bihar.

ICAR Seed Project: Seed production in agricultural crops

- During the year 2015-16, approximately 7,400 q of seed cane was produced, out of which, around 5,500 q seed cane of improved varieties of sugarcane was lifted and the rest was utilized for further multiplication and distribution to farmers.
- More than 11 ha area was planted with newly released varieties for seed cane production during 2016-17.
- Seed Awareness Programme on the occasion of World Food Day was organized on October 16, 2015 at ICAR-IISR. In this programme, 200 farmers from different districts of Uttar Pradesh were provided with seed packets of newly released variety, CoLk 9709 and a campaign was initiated for making the sugarcane growers aware about the role of quality seed cane in enhancing the yield and production. Under '*Mera Gaon, Mera Gaurav*' Scheme also, quality seed cane was a major component for the awareness.

Central Sector Scheme for PPV&FR Authority

2

High density cane farming

Optimization of plant population for improving physiological efficiency of sugarcane

A field experiment under spring planting season (crop duration of 360 days) was conducted for impacting plant population density and physiological efficiency in sugarcane plant crops, through usage of *Ethrel* and GA_3 at critical growth stages. Along with, the impact of GA_3 treated seeds on sprouting was also evaluated.

Faster heterotrophic to autotrophic transitions at planting stage (February) for establishing high initial plant population (45 DAP): CoLk 94184 was planted using sugarcane seeds derived from GA_3 treated and untreated autumn planted sugarcane crop. Both GA_3 treated and untreated setts were soaked overnight in 100 ppm *Ethrel* and planted at 75 cm spacing keeping the seed rate of 4.5 setts/m row length. Later followed by foliar applications of GA_3 at specific leaf sites in morning (9 am-11 am) @ 35 ppm solution prepared in water was carried out at 90, 120 and 150 DAP. At 45 DAP, both the setts did not exhibit any significant difference in their heterotrophic to autotrophic transitions. However, *Ethrel* priming induced faster sink to source followed by source to sink transitions, fetching 60% higher and early establishment of sink strengths at 45 DAP (settling population of 73,334 settlings ha^{-1} against 40,000 settling ha^{-1} in control (Fig 2.1). *Ethrel* induced faster transitions were ramification of a positive feedback between source and sink activities as evidenced by enhanced acid invertase and ATPase activities leading to mobilization of sucrose causing greater availability of reducing sugars.

Fig. 2.1. Initial settling establishment in spring planted sugarcane

Increasing sink strength through induction of horizontal growth at 60 DAP: Foliar application of *Ethrel* at 60 DAP led to 60.65 % increase in sink strength (82,813 settlings ha^{-1}) against control (51,562 settlings ha^{-1}) at 90 DAP. The horizontal increase in shoot numbers, was a consequence of raised carbon (carbohydrates) and nitrogen demands (NR activities *in vivo*), fulfilled by internal drawdown of photo assimilates, also supported by activation of IAAO activities and NR *in vivo* activities in silent buds against control.

Inducing smart canopy, above and below ground sink development at 90, 120 and 150 DAP: Foliar application of GA_3 at 90, 120 and 150 DAP led to increase in shoot population (T_{max} -5.37 lakh ha^{-1}). The application led to increase in leaf area (1144 cm^2 $stalk^{-1}$), foliage numbers (137 m^{-2}), and leaf angle (73°) and leaf area index (4.7) at 180 DAP. Changes in leaf angle due to GA_3 spray enabled added advantage of enhanced CO_2 utilization and radiation use efficiency compared to control. The GA_3 induced leaf orientation formed a smart canopy, diverting dry matter partitioning for enhancing tiller development at early stage. Further, leaf erectness also reduced the shading effects amongst the leaf present on a stalk, rendering increase in radiation use by lower leaf laminae of the stalk. GA_3 induced three fold increase in root weights and root hair development, sustained the nutrient requirement of increased shoot population. As a result, net assimilation rates (0.65 (cm^2 d^{-1})^5), leaf area ratio (16 cm^2 g^{-1}) and leaf area duration [55 (cm^2 d)10^4] enhanced, leading to increase in internodal numbers and lengths. The applications at 150 DAP further stretched the internodal numbers and length (Fig 2.2).

At maturity and harvest : The overall impact of these applications manifested in enhanced plant population with strengthened physiological efficiency culminating in T_{max} 5.37 lakh shoots/ha against 2.13 lakh shoots/ha in control at 180 DAP. Later, tiller survival of about 57.5 % culminated in an NMC of 3.01 lakh/ha with a cane yield of 255 t/ha (per cane weight 847 g) against tiller survival of 38 % resulting in NMC of 1.32 lakh shoots/ha with a cane yield of 84.69 t/ha in control (per cane weight 640 g). The large accommodation of stalks in limited ground area with *Ethrel* and GA_3 is explained to be due to the development of smart canopies supported by a robust root system, where each plant occupied merely 331 cm^2 ground area against 800 cm^2 in control.

Hormonal interventions in late planted sugarcane crop in three varieties (Crop duration 270 days)

A field experiment under late planting season (crop duration of 270 days) was conducted for impacting plant population density and physiological efficiency in sugarcane plant crops (Co Lk 94184, Co S 8436 and CoLk 11201), through usage of *Ethrel* and GA_3 at critical growth stages. Sugarcane varieties CoLk 94184, CoS 8436, CoLk 11201 were planted after sett priming with *Ethrel* in May after the harvest of wheat at 75 cm spacing keeping the seed rate of 4.5 setts/m row length. Later, foliar applications of GA_3 at specific leaf sites in morning (9 am-11 am) @ 35 ppm solution prepared in water were carried out at 90, 120 and 150 DAP.

Sett priming with *Ethrel* caused significant improvement in sett's vigour and sprouting in CoLk 94184 and CoS 8436. However, there was no response in CoLk 11201. Improvement in sett vigour fastened the establishment of uniform initial settlings at 45 DAP, which increased further till 90 DAP in both the CoLk 94184 and CoS 8436. The applications rendered increase in leaf numbers per plant, leaf area, internodal number per plant and internodal length by 33.3, 48.1, 22.2 and 28.5%, respectively against control in CoLk 94184 and CoS 8436. However, the impacts were not exhibited in CoLk 11201. The enhancement in internodal length was positively correlated with increased α-amylase and NR activities in *vivo*, which were found to be low in CoLk 11201. At maturity, after seven months, an increase in cane lengths and weights were recorded in CoLk 94184 and CoS 8436 against control. The applications boosted NMC to 1.76 lakh/ha with a cane yield of 140/ha (per cane weight 798 g) against NMC of 1.65 lakh/ha with a cane yield of 117 t/ha in control (per cane weight 708 g) in late planted CoLk 94184, NMC to 1.12 lakh/ha with a cane yield of 109 t/ha (per cane weight 985 g) against NMC to 1.01 lakh/ha with a cane yield of 75 t/ha in control (per cane weight 744 g) in late planted CoS 8436 and NMC to 1.01 lakh/ha with a cane yield of 84 t/ha (per cane weight 833 g) against NMC of 1.24 lakhs/ha with a cane yield of 89 t/ha in control (per cane weight 716 g) in late planted CoLk 11201 (Table 2.1).

Hormonal interventions in sugarcane Ist ratoon crop (Initiated from autumn crop duration -360 days)

Sugarcane ratoon crop (CoLk 94184) was initiated after harvest of autumn planted crop for impacting the physiological efficiency through usage of GA_3 at critical growth stages (Fig 2.3). The crop was subjected to foliar applications of GA_3 at specific leaf sites in morning (9 am-11 am) @ 35 ppm solution prepared in water at 90, 120 and 150 DAP.

Foliar applications of GA_3 at 90, 120 and 150 DAP increased stalk extension rates, internodal length and cane weight negating tiller cessation induced by dense tiller population, lipid degradation and low PAR and R:FR ratios. The impacts helped the development of assimilatory apparatus (LAR > 34) and thereby increased the vertical growth of the stalks (Fig 2.4 & 2.5). The above ground growth and development of the shoots were supported by heavy proliferation of root biomass (root weight > 60 g per plant against 20 g in control. The application of GA_3 also increased the soil microbial population (nitrogen fixers), IAA levels and phyto siderophores production increasing the nutrient availability and its transport to sustain the enhanced vertical growth of stalks. The impacts in Ist ratoon crop initiated from autumn planted crop resulted in NMC of 2.68 lakh/ha with a cane yield of 158 t / ha (per cane weight 592 g) against NMC of 1.53 lakh/ha with a cane yield of 99.67 t/ha in control (per cane weight 651g).

Fig. 2.4. Improved vertical growth in Ist ratoon crop initiated from autumn planted crop

Table 2.1. Impact of hormonal (Ethrel + GA_3) applications on growth attributes and juice quality in sugarcane plant and ratoon crops of varying crop durations at ICAR-IISR, Lucknow

Treatment	Variety	Corrected °Brix	Sucrose %	Purity Coefficient	Wt (g) per cane	Wt of juice (Kg/5 canes)
Sugarcane plant crop (Spring planted, Crop growth duration - 360 days)						
Ethrel + GA_3	CoLk 94184	21.53	18.31	87.35	1038	2.390
Control	CoLk 94184	18.65	15.53	83.27	488	0.997
Sugarcane plant crop (Late planted, Crop growth duration - 270 days)						
Ethrel + GA_3	CoLk 94184	20.24	17.98	88.84	897	1.77
Control	CoLk 94184	19.07	16.26	85.23	700	1.32
Ethrel + GA_3	CoS 8436	19.73	17.40	88.19	985	2.57
Control	CoS 8436	19.50	17.20	88.22	744	1.85
Ethrel + GA_3	CoLk 11201	20.41	17.88	87.59	838	2.054
Control	CoLk 11201	18.58	16.24	87.38	716	1.814
Ist Ratoon crop (Initiated after harvest of autumn plant crop, Crop growth duration - 270 days)						
GA_3	CoLk 94184	22.54	19.60	87.03	877	2.120
Control	CoLk 94184	19.72	16.61	84.24	722	1.688
Ist Ratoon crop (Initiated after harvest of late planted crop, Crop growth duration - 270 days)						
GA_3	CoLk 94184	22.01	19.58	89.01	930	2.12
Control	CoLk 94184	21.16	18.77	88.75	570	1.17

Hormonal interventions in sugarcane I ratoon crops (Initiated from late planted crop - duration- 270 days)

Sugarcane ratoon crop (CoLk 94184) was initiated after harvest of late planted crop for impacting the physiological efficiency through usage of GA_3 at critical growth stages. The crop was subjected to foliar applications of GA_3 at specific leaf sites in morning (9 am-11 am) @ 35 ppm solution prepared in water at 90, 120 and 150 DAP. Foliar

Isolation and activity study of plant growth promoting rhizobacteria (PGPR): The soil samples were collected from the root-free soil rhizosphere from the different fields of ICAR-IISR research farm and bacteria were isolated employing serial dilution plate technique using nutrient agar. Colonies exhibiting prolific growth were selected for further streaking on fresh agar plates for purification and multiplication of the isolates. A total 100 bacterial isolates were obtained. These bacterial isolates were

(A) (B) (C)

Fig. 2.6. Serial dilution plate technique to isolate bacteria (A), production of siderophore (B) and production of HCN (C)

Use of plant growth regulators (PGRs) for enhanced yield and quality of sugarcane

A field experiment of All India Coordinated Research Project (AICRP) on Sugarcane on use of plant growth regulators (PGRs) on yield and quality of sugarcane was conducted during the year 2015-16 at IISR research farm, Lucknow. The planting of sugarcane was done during the spring season of 2015 and the crop was harvested after twelve months. The experiment consisting eight treatments *viz.*, conventional planting /farmers practice (3-bud setts), planting of setts after overnight soaking in water, planting of setts after overnight soaking in 50 ppm ethrel solution, planting of setts after overnight soaking in 100 ppm ethrel solution, T_1+ GA_3 spray (35 ppm) at 90, 120 and 150 days after planting (DAP), T_2+ GA_3 spray (35 ppm) at 90, 120 and 150 DAP, T_3+ GA_3 spray (35 ppm) at 90, 120 and 150 DAP and T_4+ GA_3 spray (35 ppm) at 90, 120 and 150 DAP. The experiment was conducted in a randomised block design (RBD) with three replications. The recommended dose of nitrogen 150 kg, phosphorus 60 kg and potash 60 kg per hectare was applied in all the treatments. The experimental field soil was analyzed alkaline in soil reaction, neutral in electrical conductivity, low in organic carbon, available nitrogen and medium in available phosphorus and potassium. The DTPA extractable micronutrients *viz.*, Zn, Cu, Fe and Mn were above to their critical limits. The sugarcane setts overnight soaking in 50 and 100 ppm ethrel solution enhanced early sugarcane germination as compared to that of control and water soaked treatments. The GA_3 application at the rate of 35 ppm application at 90, 120 and 150 days after planting enhanced cane length, number of millable cane and cane yield. The treatment planting of setts after overnight soaking in 100 ppm ethrel solution and GA_3 spray at 90, 120 and 150 days after planting recorded significantly higher cane yield (96.67 t/ha). The same treatment also recorded higher cane length (243 cm), diameter (2.16 cm), weight (910 g) and number of millable cane (146.8 thousand/ha). Whereas, the cane diameter and juice quality parameters *viz.*, brix, (sucrose %, purity % and commercial cane sugar % were not affected significantly due to use of plant growth regulators in sugarcane.

3

Natural resource management

Tillage techniques in plant-ratoon system for improving soil health and increasing sugarcane yield in subtropical India

An experiment in 2nd cropping season was initiated in February 2014. Before planting of sugarcane, subsoiling (up to depth of 45-50 cm) and deep tillage through mold board plough (up to 20-25 cm depth) as per treatments were applied on experimental field. After planking, furrows were opened at 75 cm row spacing for sugarcane planting. Post plant tillage treatments/hoeing and integrated weed management practice were followed in plant cane to increase input use efficiency and sustain soil health in sugarcane (plant)-ratoon system as per treatments. Thus, eight treatment combinations were applied in main plots in Split Plot Design. Three treatments of trash mulching/integrated weed management in ratoon crop were superimposed in sub plots. Sugarcane variety CoPk 05191 was planted on February 06, 2014 in the experiment. Initial level of soil fertility indicated that soil had 0.50% OC, 323.2 kg available N/ha, 57.1 kg available P_2O_5/ha and 378.9 kg K_2O/ha.

Results on sugarcane ratoon crop revealed that deep tillage and subsoiling followed by harrowing before sugarcane planting produced the highest number of millable canes (1,32,100/ha), mean cane length (231.2 cm), cane diameter (2.23 cm) and cane weight (973.3 g) of sugarcane ratoon (Table 3.1). An increase of 28.10% in ratoon cane yield (117.6 t/ha)

Table 3.1. Effect of different treatments on sugarcane growth, yield and soil health parameters at harvest stage

Treatment	NMC (000/ha)	Cane length (cm)	Cane diameter (cm)	Cane weight (g)	Ratoon cane yield (tonne/ha)	Soil quality parameters at harvest			
						SOC content (%)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
A. Pre plant tillage operation (Plant Cane) Ax B in Main Plot									
T_1	119.8	214.0	2.19	923.3	103.3	0.43	236.8	19.88	344.0
T_2	132.1	231.2	2.23	973.3	117.6	0.44	232.9	19.51	330.8
T_3	116.9	220.2	2.21	925.6	94.7	0.52	265.3	23.53	318.3
T4	125.1	199.0	2.21	904.4	91.8	0.48	226.9	21.07	293.2
SEm±	2.60	3.56	0.04	15.42	1.62	0.008	4.52	0.35	5.62
CD(P=0.05)	7.86	11.42	0.12	46.85	4.86	0.026	12.43	1.10	16.52
B. Post plant tillage/operation (Plant Cane)									
I_1	128.1	222.3	2.19	923.3	105.6	0.46	230.9	19.82	293.0
I_2	118.8	213.6	2.23	940.0	98.1	0.48	243.0	22.18	350.3
SEm±	2.23	3.14	0.003	13.42	1.47	0.081	3.86	0.33	4.52
CD (P=0.05)	6.85	9.52	0.10	38.56	4.26	0.024	11.42	0.95	14.5
C. Trash mulching/Intercultural operation (Ratoon Cane) Sub Plot									
M_1	123.5	221.5	2.20	951.7	100.4	0.45	217.2	20.28	302.4
M_2	127.73	220.5	2.22	880.8	102.7	0.47	244.6	20.28	323.3
M_3	119.2	215.0	2.22	962.5	102.6	0.50	259.7	21.90	339.2
SEm±	1.90	2.80	0.003	11.50	1.75	0.007	3.80	0.28	4.12
CD (P=0.05)	5.84	8.62	0.08	32.5	4.10	0.020	10.76	0.86	12.50

Note : T_1 Deep ploughing (20-25 cm) followed by harrowing; T_2 Subsoiling (45-50 cm), disc ploughing and harrowing T_3 Direct planting at optimum soil moisture through SCP; T_4 Control (Farmers practice); I_1 Three manual hoeing; I_2 Integrated Weed Management (Atrazine 2 kg ai/ha (Pre emergence) followed by 2-4, D 1 kg ai/ha (post emergence) and one hoeing at (90 DAP) ($T \times I$ applied in plant cane); M_1 Three manual hoeings from ratoon initiation to close in period ; M_2 One hoeing at ratoon initiation followed by atrazine (pre emergence) at optimum moisture and 2-4 D (post emergence) application; M_3 Trash mulching in ratoon crop with application of *Trichoderma, Gluconacetobacter, Pseudomonas* (microbial consortia) application (M applied in ratoon cane). Treatments were applied in sugarcane (plant) - ratoon system.

was obtained with adoption of this practice over the control. The maximum soil organic carbon (0.52%), available N (265.3 kg N/ha), P_2O_5 (23.53 kg/ha) and K_2O (318.3 kg/ha) at the harvest were analyzed where direct planting through Sugarcane Cutter Planter was done.

Trash mulching in ratoon crop with application of microbial consortia (*Trichoderma, Gluconacetobacter* and *Pseudomonas*) improved growth and yield attributes besides improving the soil health parameters. The highest individual cane weight (962.5 g) was recorded with application of microbial consortia (*Trichoderma, Gluconacetobacter* and *Pseudomonas*). However, all the treatments applied in ratoon crop produced yield at par (100.4-102.6 t/ha). One hoeing at ratoon initiation followed by atrazine (pre emergence) at optimum moisture and 2-4 D (post emergence) application (M_2) produced the highest number of millable canes. However, these were found at par with three manual hoeings (M_1). Trash mulching with application of microbial consortia (*Trichoderma, Gluconacetobacter* and *Pseudomonas*-M_1) showed the highest soil organic carbon content(0.50%), available N (259.7 kg/ha), available P_2O_5 (21.90 kg/ha) and available K_2O (339.2 kg/ha) after harvesting of ratoon crop in sugarcane (plant)-ratoon system. This showed that conservation practices produced the ratoon cane yield at par *vis-a-vis* sustaining soil quality for longer period.

Carbon sequestration potential of sugarcane based cropping system for sustaining soil health and crop productivity

Sugarcane planting was done on 15th April 2014 as succeeding crop in sugarcane-ratoon-wheat and rice-wheat-rice-wheat cropping systems. There were four levels of seed cane material (S_1: conventional 3 bud setts, S_2: sett soaking in water for whole night, S_3: sett soaking in 100 ppm ethrel solution for 4 hrs and S_4: foliar application of 100 ppm ethrel and mixture of 1% urea on seed cane, one week prior to planting) and 2 levels of microbial consortia (M_1: control; M_2: Application of microbial consortia (PSB+ *Gluconacetobacter* + *Trichoderma*). Thus, eight treatments were applied in sugarcane plant crop. After harvesting of plant crop, ratoon was initiated in the month of March 2015 and the two treatments of N management T_1: 50% RD of Nitrogen+ Consortia (*PSB+ Acetobacter +Trichoderma*), T_2 : 100% RD of Nitrogen were superimposed.

Table 3.2. Effect of different nutrient levels on growth, yield attributes and sugar yield of ratoon crop

Treatment*	Millable canes (000/ha)	Cane length (cm)	Cane diameter (cm)	Cane weight (g)	°Brix	Pol (%) juice	Purity (%)	Cane yield (t/ha)	CCS (tonne/ ha)
A. Seed Treatment (Plant cane)									
S_1	124.3	155.6	1.97	488.3	18.23	15.55	84.98	68.0	7.19
S_2	119.6	155.5	1.88	440.0	19.10	16.41	85.88	65.02	7.28
S_3	112.6	149.5	2.03	460.0	18.28	15.44	84.49	64.14	6.70
S_4	131.3	152.8	1.95	433.3	18.20	15.04	82.72	65.68	6.61
SEm±	4.30	5.53	0.05	35.30	0.39	0.47	1.57	2.85	0.14
CD (P=0.05)	10.52	NS	NS	NS	NS	NS	NS	NS	0.30
B. Microbial Consortia (Plant cane)									
M_1	122.9	67.43	151.3	459.2	18.53	18.53	83.56	67.43	9.12
M_2	120.9	63.99	155.4	449.2	18.38	18.38	85.47	63.99	8.59
SEm±	5.18	2.11	5.87	25.56	0.11	0.11	1.54	2.11	0.16
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	0.34
C. Trash mulching/Intercultural operation (Ratoon cane)									
T_1-	122.01	66.19	151.3	455.8	18.39	18.39	84.20	66.19	8.89
T_2	121.9	65.22	155.5	452.5	18.51	18.51	84.83	65.22	8.81
SEm±	3.72	2.34	4.90	20.97	0.24	0.24	1.62	2.34	0.18
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

*A: S_1 - Control (3 bud setts), S_2 - Sett soaking in water S_3- Sett soaking in 100 ppm ethrel for 4 hrs, S_4 - Foliar application of 100 ppm ethrel and 1% urea on seed cane one week prior to planting; B: M_1 - Control, M_2 - Consortia application (PSB+*Gluconacetobacter*+*Trichoderma*); C: T_1: 50% RD of Nitrogen + Consortia (PSB+*Acetobacter*+*Trichoderma*), T_2: 100% RD of Nitrogen

Experimental results on sugarcane ratoon crop (Table 3.2) revealed that sugarcane growth attributes, millable canes, length, diameter and individual cane weight were not influenced significantly by seed soaking treatments applied in plant crop. Application of microbial consortia (*PSB + Gluconacetobacter + Trichoderma*) over conventional fertilization without biofertilizer did not influence the growth, ratoon cane and sugar yields significantly. However, in ratoon crop, 50% N application through chemical fertilizer along with microbial consortia (*PSB+Acetobacter+ Trichoderma*) was found at par with 100% N application through chemical fertilizer. Thus, 50% saving of N (100 kg/ha) in sugarcane ratoon crop was observed through integration of microbial consortia with chemical fertilizer.

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

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

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. The experimental field consisted of plots (8x6 m) with varying 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. Land in all the plots was separately prepared to avoid any possible mixing. Farmyard manure was added in the stipulated plots at the time of final ploughing for land preparation. Soil and plant samples were drawn at different intervals to record soil physical, physico-chemical, microbial properties and plant biometric parameters.

Varying initial SOC levels did not influence the germination nor was it affected by the different management practices. However, the interaction effect of these two (Table 3.3) on germination (%) was found significant as addition of FYM at lower SOC level (0.45-0.55%) brought about significant improvement (40.6) over that with RDF (24.4). Higher initial SOC content (0.66-0.75%) ensured significantly higher sugarcane germination (40.4%) over that under the lowest SOC (24.4%) when only RDF was applied. Effect of treatments on tillering was conspicuous as the highest number of tillers (000/ha) at 70 and 160 DAP was recorded (158 and 137.8, respectively) under initial SOC level of 0.66-0.75% that were significantly higher over the number of tillers obtained with 0.45-0.55% initial SOC level (Table 3.4). Further there was no increase in tiller population for SOC content beyond 0.76%. Addition of 10 t/ha FYM along with RDF caused significant improvement in tiller density over the RDF alone at both the stages across different initial SOC levels. Addition of zinc sulphate and sulphur could not evince significant influence.

Among the yield attributing characters as observed at harvest, the number of millable canes (NMC) was significantly affected due to varying initial SOC content. Significant increase in NMC (110.2 thousand/ha) was recorded up to initial SOC content of 0.66-0.75 % with no further increase with increasing initial SOC. The cane length and thickness were not influenced by initial SOC levels, however, there was significant enhancement in cane length and thickness owing to farmyard manure or zinc sulphate and sulphur application along with RDF over that of RDF alone. The highest sugarcane yield (70.9 t/ha) was recorded under SOC level of 0.66-0.75% which was significantly higher than that recorded with SOC levels of 0.56-0.65 % (64.1 t/ha) and 0.45-0.55 % (62.1 t/ha). Interaction effect was not significant on yield attributes and cane yield. Juice quality also remained unchanged due to various treatments.

Table 3.3. Effect of interaction between initial SOC and nutrient management on germination (%) of sugarcane

Initial SOC content (%)	Nutrient management practice			Mean
	RDF	RDF + FYM	RDF + $ZnSO_4$ + S	
0.45-0.55	24.4	40.6	22.9	29.3
0.56-0.65	33.5	36.7	32.5	34.2
0.66-0.75	40.4	35.5	31.4	35.7
> 0.76	30.1	33.4	30.7	31.4
Mean	32.1	36.4	29.3	

Table 3.4. Effect of initial soil organic carbon content (SOC) and nutrient management on growth and yield of sugarcane

Treatment	Germination (%)	Tiller no. ('000/ha)		NMC ('000/ha)	Cane length (m)	Cane diameter (cm)	Cane yield (t/ha)
		70 DAP	160 DAP				
Initial SOC content							
0.45-0.55	29.3	124.5	122.5	85.7	1.86	1.90	62.1
0.56-0.65	34.2	143.6	127.2	103.3	1.91	2.04	64.1
0.66-0.75	35.7	158.0	137.8	110.2	1.92	2.13	70.9
>0.76	31.4	149.1	137.0	111.6	1.96	2.11	70.2
SE ±	3.0	8.9	5.4	3.1	0.09	0.11	2.0
CD (P=0.05)	NS	18.6	11.4	6.6	NS	NS	4.6
Nutrient Management							
RDF (150, 60, 60)	32.1	132.8	125.0	100.1	1.79	1.96	63.0
RDF + FYM (10 t/ha)	36.4	152.8	139.4	107.6	1.98	2.05	69.5
RDF + $ZnSO_4$ 25 kg + S 20 kg/ha	29.3	145.8	128.9	100.4	1.96	2.12	67.9
SE ±	2.6	7.7	4.7	2.7	0.07	0.09	1.9
CD (P= 0.05)	NS	16.1	9.7	5.7	0.16	NS	4.0

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

Field experiment was conducted to develop nutrient management strategy for sustaining soil health and sugarcane production. The experiment consisted of 10 treatments. The experiment was laid out in Randomised Block Design with three replications.

The data on first ratoon of sugarcane growth, yield and quality parameters (Table 3.5 and 3.6) indicated significant variations among the treatments. The highest rate of ratoon stubble sprouts (92.6%) was observed under the treatment of only organic application followed by 20 t FYM + STRC nutrient application. The highest number of tillers (254.9 thousand/ha at 120 days after initiation), shoot count (210.7 thousand/ha at 180 DAI), number of millable canes (167.9 thousand/ha), cane yield (91.7 t/ha) and sugar yield (11.07 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.*, length (225.3 cm), diameter (2.34 cm) and weight of individual cane (1.03 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 and pol % juice were significantly improved with application of FYM and biofertilizers.

Effect of integration of microbial consortia with inorganic on sugarcane growth, yield and quality in subtropical India

A field experiment was conducted during 2014-16 at ICAR-IISR, Lucknow to determine the combined effect of microbial consortia and pesticide applied in sugarcane crop. Sugarcane variety Co 0238 was planted in the experiment on 12th February 2014. There were three treatments applied under seven replications in RBD. Treatments *viz.*, T_1 (Recommended NPK through inorganic fertilizer only); T_2: T_1+ Chlorpyriphos + Bavistin; T_3: T_2+ microbial consortia (*Gluconacetobacter + PSB+Trichoderma*) were applied in microplots. Same treatments were applied to ratoon crop.

Tiller population in ratoon crop (2015-16) increased up to May, and after that declined continuously up to October. The maximum tiller population (186.5 thousand /ha) was counted in the month of May with integration of recommended NPK through inorganic fertilizer only (200 kg N/ha), + Chlorpyriphos (for termite control)+ Bavistin (for seed treatment)+ microbial consortia (*Gluconacetobacter+ PSB+Trichoderma*). Tiller population increased @ 12.93% (186.5 thousand/ha) with integration of all the inorganic with biofertilisers as compared to control (T_1: recommended NPK only). The highest number of millable canes (91.44 thousand/ha), individual cane length (283.0 cm), cane diameter (2.81 cm) and cane weight (1540 g) were observed with integration of inorganic (chemical fertilizer and pesticide) and

Table 3.5. Growth and yield of first ratoon cane under different treatments

Treatment	Sprouts %	May (000/ha)	June (000/ha)	July (000/ha)	August (000/ha)	September (000/ha)	October (000/ha)	NMC (000/ha)	Yield (t/ha)
T_1:T-10+50% RDF	83.7	140.6	156.7	180.4	171.6	160.8	155.9	110.70	57.60
T_2:T-10+100% RDF	85.9	170.7	185.4	215.7	216.8	190.6	167.6	129.50	73.40
T_3:T-10+STBR	85.3	172.3	184.6	216.6	204.9	185.7	175.8	135.40	76.80
T_4:20 t 50% RDF	87.4	176.9	181.2	220.7	209.7	186.9	169.8	129.60	74.40
T_5:20 + 100% RDF	88.3	190.2	204.7	234.5	226.7	204.8	196.2	155.70	87.60
T_6:20 + STRC	89.2	202.4	228.7	254.9	246.9	210.7	197.6	167.90	91.70
T_7:10+ B +50% RDF	86.4	159.6	174.2	202.7	191.4	172.6	159.5	112.90	65.60
T_8:10+B+100%RDF	88.5	179.7	197.4	226.9	215.7	197.8	182.9	159.70	75.90
T_9:10+ B+STBR	87.6	187.6	201.8	232.5	223.6	205.7	185.6	163.40	89.70
T_{10}: Organic	92.6	146.7	160.2	194.6	196.3	189.5	167.9	122.60	82.70
SEm±	1.16	3.77	3.24	3.63	4.35	3.55	4.82	3.22	2.42
CD (P= 0.05)	3.46	11.29	9.59	10.76	12.89	10.53	14.26	9.54	7.29

T_1- Application of trash @10 t/ha + 50% RDF (recommended dose of fertilizer): T-10+50% RDF, T_2-Application of trash @ 10 t/ha + 100% RDF : T-10+100% RDF, T_3-Application of trash @ 10 t/ha + soil test based recommendation: T-10+STBR, T_4-Application of FYM @ 20 t/ha + 50% RDF (inorganic source) : 20 t + 50% RDF, T_5-Application of FYM @ 20 t / ha + 100% RDF (inorganic source) : 20 t + 100% RDF, T_6-Application of FYM @ 20 t/ha + inorganic nutrient application based on soil test : 20 t + STRC, T_7-Application of FYM @ 10 t /ha + biofertilizer (*Acetobacter + PSB*) + 50% RDF : 10 t + B + 50% RDF, T_8-Application of FYM @ 10 tonne/ha + biofertilizer (*Acetobacter + PSB*) + 50% RDF : 10 t + B + 100% RDF, T_9-Application of FYM @ 10 t/ha + biofertilizer (*Acetobacter + PSB*) + inorganic nutrient application based on soil test : 10 t + B + STBR, T_{10}-Only organic : Organic.

Table 3.6. Effect of different treatments on juice quality, ratoon cane yield attributes and sugar yield

Treatment	Brix (%)	Pol % (%)	Purity (%)	Length (cm)	Girth (cm)	Cane wt. (kg)	CCS (%)	CCS (t/ha)
T_1: T-10+50%RDF	19.12	15.59	85.44	190.60	2.11	0.83	10.35	5.96
T_2: T-10+100%RDF	19.11	15.98	85.05	210.75	2.17	0.87	10.75	7.89
T_3: T-10+STBR	19.83	16.20	85.74	215.69	2.28	0.87	10.77	8.27
T_4: 20+50% RDF	19.28	16.30	84.41	201.33	2.24	0.93	11.03	8.20
T_5: 20+100% RDF	19.99	17.31	86.56	220.70	2.25	0.95	11.85	10.38
T_6: 20+STRC	19.80	17.47	85.97	225.30	2.34	1.03	12.07	11.07
T_7: 10+B+50%RDF	19.59	16.75	85.50	200.60	2.21	0.83	11.39	7.47
T_8: 10+B+100%RDF	19.62	16.76	85.26	210.72	2.26	0.96	11.40	8.65
T_9: 10+B+STBR	19.16	16.35	85.29	222.70	2.31	0.99	11.11	9.97
T_{10}:Organic	19.90	17.13	86.11	203.00	2.30	0.90	11.70	9.67
SEm ±	0.19	0.35	0.24	3.84	0.03	0.03	0.31	0.44
CD(P= 0.05)	0.58	1.10	0.69	11.29	0.12	0.10	0.94	1.31

biofertilisers (Table 3.7). Thus, the highest sugarcane ratoon and sugar yields (92.58 tonne/ha and 15.27 tonne/ha, respectively) were obtained with T_8 (T_2+ Microbial consortia (*Gluconacetobacter + PSB + Trichoderma*). This showed that there was positive influence of application of biofertilizers with chemical pesticide also and it helped in maximizing cane and sugar yields. Juice quality parameters (sucrose% in juice and purity) could not be significantly influenced by various treatments. However, marginal increase in °brix was recorded with integration of inorganic and organic (biofertilizers).

Assessing nutrient interactions for sustaining sugarcane productivity and soil health

A field experiment of second year for assessing nutrient interaction effect of nitrogen and potassium on sugarcane was conducted during spring season of 2015-16 at ICAR-IISR, research farm, Lucknow. The four levels of each nutrient *i.e.*, 0, 100, 150 & 200 kg N/ha and 0, 30, 60 & 90 kg K_2O/ha were taken in the study. Experiment was conducted under Randomized Block Design (Factorial). Initial experimental field soil was low in organic carbon, available nitrogen and medium in available phosphorus and potash with pH

Table 3.7. Effect of different treatments on sugarcane ratoon growth, yield attributes and sugar yield

Treat-ment	NMC (000/ha)	Cane length (cm)	Cane diameter (cm)	Cane weight (g)	Cane yield (t/ha)	No. of internodes/ cane	Internode length (cm)	°Brix	Sucrose (%) juice	Purity (%)	CCS (t/ha)
T_1	76.71	251.7	2.49	1010.0	76.04	19.53	10.52	19.77	18.38	92.45	9.89
T_2	87.40	271.0	2.56	1260.0	91.0	23.07	12.23	20.82	18.31	91.73	11.50
T_3	91.44	283.0	2.81	1540.0	110.11	25.07	13.05	21.13	19.61	92.58	15.27
SEm±	3.575	4.68	0.07	14.14	1.534	0.375	0.497	0.118	0.482	0.452	0.52
CD (P=0.05)	9.92	11.43	0.19	39.26	4.25	1.04	1.305	0.329	NS	NS	1.56

8.78 and electrical conductivity 0.26 dSm^{-1}. It was observed that germination in sugarcane was not affected by either nitrogen or potassium application. However, shoot population at 180 DAP was significantly higher at 100 kg N/ha as compared to control. The shoot population at 100 kg, 150 kg and 200 kg N/ha were at par (Table 3.8). The interaction effect of nitrogen and potash was not found significant on plant growth, yield and yield contributing parameters as well as on cane juice quality. Individually, both the nutrients significantly affected different parameters of cane growth, yield and yield contributing characters.

The cane yield was significantly higher (69.6 t/ha) in the treatment of 150 kg N/ha over 100 kg N/ha due to improvement in NMC, cane length and cane weight. However, cane length and cane weight was statistically at par with 150 kg and 100 kg N/ha. Application of potassium at 30 kg K_2O/ha significantly enhanced cane yield over control. Further, increase in potassium level could not improve cane yield to the level of significance. The juice quality parameters *viz.*, °brix, sucrose % and purity % were not affected significantly due to different treatment doses of nitrogen and potash.

Another field experiment was conducted to study the interaction effect of phosphorus and zinc in sugarcane at ICAR-IISR, Lucknow Research Farm during the spring season of 2015-16 with above soil fertility conditions. The four levels of each nutrient *i.e.*, 0, 30, 60 & 90 kg P_2O_5/ha and 0, 15, 30 & 45 kg $ZnSO_4.7H_2O$/ha were taken in the study. The experiment was conducted under Factorial RBD. The application of phosphorus at 30 kg P_2O_5/ha significantly enhanced cane yield over control. The effect of further increase in phosphorus level was not significant. The application of 15 kg Zn/ha along with 30 and 60 kg P_2O_5/ha enhanced cane yield over 30 and 60 kg P_2O_5/ha without zinc. However, application of Zn alone could not influence the cane yield. A negative interaction between P and Zn was observed at higher level of zinc application. Zinc at 45 kg/ha reduced cane yield over 15 kg/ha at phosphorus level of 60 kg/ha (Table 3.9) due to the antagonism between

Table 3.8. Effect of nitrogen and potash on growth, yield attributes and yield of sugarcane

Treatment	Germination at 45 DAP (%)	Shoot count at 180 DAP ('000/ha)	Cane length (cm)	Cane diameter (cm)	Cane weight (g)	NMC (000/ha)	Cane yield (t/ha)
Nitrogen level (N kg/ha)							
0	35.94	177.87	163.67	1.77	484	138.1	57.7
100	37.24	190.93	177.67	1.82	529	153.1	65.0
150	36.26	196.30	185.75	1.81	539	160.4	69.6
200	36.63	197.55	189.50	1.82	535	162.7	70.8
SEm±	0.98	3.36	3.18	0.03	12.74	3.66	1.43
CD (P= 0.5)	NS	9.71	9.20	NS	36.79	10.56	4.12
Potassium level (K_2O kg/ha)							
0	36.02	187.27	175.08	1.79	497	152.8	60.6
30	35.30	190.60	180.92	1.82	519	151.8	65.5
60	37.76	192.22	180.67	1.80	537	154.6	68.3
90	36.98	192.55	179.92	1.82	535	155.1	68.8
SEm±	0.98	3.36	3.18	0.03	12.74	3.66	1.43
CD (P= 0.5)	NS	NS	9.20	NS	36.79	10.56	4.12

Zn and P. The juice quality parameters *viz.*, brix, sucrose % and purity % were not affected significantly due to different treatment doses of phosphorus and zinc.

Soil quality assessment under different sugarcane growing systems

Assessment of soil quality in different sugarcane growing systems in various practices of fertilizers application, ten villages (Block-Biswan, District-Sitapur) were selected for the collection of soil samples. Soil samples were collected at active growth stages of sugarcane growth in the month of September, 2015.

On the basis of average mean values, soil pH and EC values were almost similar in all the system of sugarcane growing area. However, soil organic carbon, available N and K were slightly lower where recommended doses of fertilizers (RDF) applied in all the conditions. The highest SOC, available N and K were recorded in waterlogged conditions whereas the lowest was in sub-optimum condition under both the practices. In contrast to N and K, available P was the highest in suboptimal conditions under farmers practice (FP) but recommended dose of fertilizer application recorded the highest available P in all the sugarcane growing conditions, being the highest with waterlogging conditions (Table 3.10). Available S was almost similar in all the conditions in both PF and RDF. All the micronutrient showed sufficient range in different sugarcane growing systems in both the practices of fertilizers application. Zinc content in soil was slightly higher in farmers' practices as compared to RDF but waterlogging condition exhibited the highest Zn content than that of sub-optimum and optimum conditions. However, Cu content was higher in RDF than FP under waterlogging condition. However, Fe and Mn content were slightly higher in FP than RDF in all the growing conditions of sugarcane. Boron content was almost similar in all the conditions. Bacterial and actinomycetes counts were higher in RDF as compared to FP in all the systems of sugarcane growing areas. The greatest counts of bacteria and actinomycetes were found in optimum condition and the lowest was in waterlogging conditions of sugarcane growing system. Fungal counts were higher in FP than RDF but the highest in optimum conditions in both the conditions whereas *Azotobacter* counts were in optimum conditions followed by suboptimum condition and least in water logging conditions (Table 3.11).

Table 3.9. Response of sugarcane in terms of yield (t/ha) to phosphorus under different Zn levels

Nutrient level (P_2O, kg/ha)	0 kg Zn/ha	15 kg Zn/ha	30 kg Zn/ha	45 kg Zn/ha	Mean
0	64.2	66.8	68.8	68.3	67.0
30	68.6	72.2	72.7	69.5	70.8
60	71.7	75.3	72.3	70.0	72.3
90	71.0	73.6	72.9	69.8	71.8
Mean	68.9	72.0	71.7	69.4	

CD to compare effect of Zn at same level of P and effect of P at same level of Zn = 3.04

CD (P=0.05) to compare mean values under phosphorus and Zinc levels = 4.29

Table 3.10. Effect of different sugarcane growing system on physico-chemical properties of soil in Sitapur district

Condition	pH (1:2.5)		EC (dSm^{-1})		SOC (%)		N ($kg\ ha^{-1}$)		P ($kg\ ha^{-1}$)		K ($kg\ ha^{-1}$)		S ($kg\ ha^{-1}$)	
	FP	RDF	FP	RDF	FP	RDF	FP	RDF	FP	RDF	FP	RDF	FP	RDF
Sub-optimum	7.36	7.34	0.12	0.14	0.46	0.39	227.0	220.6	24.30	20.61	98.8	91.2	12.21	11.34
Optimum	7.43	7.51	0.11	0.10	0.51	0.42	239.5	227.04	22.21	21.05	110.0	102.3	14.21	12.55
Waterlogging	7.32	7.22	0.13	0.11	0.60	0.55	245.9	234.77	18.71	25.26	126.1	118.1	12.56	12.59

Table 3.11. Effect of different sugarcane growing systems on micronutrient and microbial activity in Sitapur district

Condition	Zn		Cu		Fe (mg/kg)		Mn		B		Bacteria (10^6 cfu)		Actinomycetes (10^5 cfu)		Fungi (10^4 cfu)		*Azotobacter* (10^4 cfu)	
	FP	RDF	FP	RDF	FP	RDF	FP	RDF	FP	RDF	FP	RDF	FP	RDF	FP	RDF	FP	RDF
Sub-Optimum	1.38	1.16	1.56	1.83	102.3	94.26	14.21	13.18	2.21	2.31	7.69	8.98	5.57	7.32	101.7	34.56	10.35	8.76
Optimum	1.30	1.22	1.66	1.89	91.08	88.43	12.71	12.23	2.32	2.25	6.12	8.67	6.12	9.73	112.2	57.17	13.21	16.69
Water-logging	1.43	1.45	2.06	1.96	95.98	81.62	12.85	11.71	2.29	2.39	4.28	5.08	5.47	8.14	98.36	20.71	8.61	4.47

Soil test and Resource based Integrated Plant Nutrient Supply System for Sustainable Sugarcane Production

Field experiment was conducted on alluvial soils to develop targeted yield equations (var. CoPk 05191) and to assess the fertility status, fertilizer requirements, and formulation with and without integrated plant nutrient supply fertilizer (IPNS) prescription equation for sugarcane production on soil-test and yield target bases. By using cane yields, initial soil-test values, uptake of nutrients, and fertilizer doses applied, the basic data [*viz.*, nutrient requirement (NR) and contributions of nutrients from soil (Cs), fertilizers (Cf), and farmyard manure (Cfym)] were computed and used to develop fertilizer prescription equations for sugarcane production. The results of the present investigation revealed that 2.05, 0.65 and 2.83 kg of N, P, and K were required for the production of one tonne of sugarcane (Table 3.12). It was found that soil has contributed the greatest percentage of N (52.0%), P (122.8%) and K (74.22%) towards the total N, P and K uptake by sugarcane. However, the contribution of N, P, and K from the fertilizer was 35.46, 66.79 and 139.2% whereas the contribution of N, P and K from organic manures were 19.57, 5.12 and 25.81% towards uptake of N, P and K, respectively.

Evaluation of microbial mapping and their correlation on productivity, plant and soil health in major cropping systems of Uttar Pradesh

Soil samples collected in the rhizosphere of pulses, mustard, wheat and potato showed similar type of soil texture (clay, silt and sand) in pulses and mustard whereas wheat and potato rhizosphere had almost similar soil texture. Wheat rhizosphere had the highest soil pH (8.03) followed by potato (7.80). EC value was the highest in case of potato rhizosphere (0.76 dSm^{-1}) followed by wheat (0.44 dSm^{-1}). The SOC ranges from 6.20 to 7.73 g kg^{-1} in the rhizosphere of pulses, mustard, wheat and potato selected for the study. The highest SOC was recorded with pulses rhizosphere (7.3 g kg^{-1} soil) followed by mustard (7.10 g kg^{-1} soil) whereas the lowest was in potato rhizosphere. The highest available nitrogen was found in the rhizosphere of potato followed by mustard and the lowest with in wheat. Available P was recorded the highest in potato followed by wheat but lowest in pulses rhizosphere. However, the highest available K was found in mustard rhizosphere followed by pulses. All the micronutrients *viz.*, Zn, Cu, Fe and Mn were found higher over the sufficiency range in all the rhizosphere (Table 3.13). The highest Zn content was found in the rhizosphere soil of pulses whereas the highest Cu and Fe content was found in potato rhizosphere but mustard recorded the highest Mn content. Rhizosphere soils of pulses were dominated in respect of most of the microbial and enzymatic activity *viz.*, SMBC, SMBN, qCO2, DHA, FDHA, microbial counts *viz.*, bacterial, actinomycetes, fungal and *Azotobacter* counts. However, alkaline and acid phosphatise activities was recorded the highest in the rhizosphere soil of wheat followed by pulses (Table 3.14). Forty strains of *Pseudomonas spp.* isolated from the sugarcane rhizosphere analyzed different

Table 3.12. Targeted yield equation of spring planted sugarcane (Var. CoPk 05191)

Basic data	N	P	K
Nutrient requirement (kg/ tonne cane)	2.05	0.65	2.83
Soil efficiency (%)	52.0	122.8	74.72
Fertilizer efficiency (%)	35.46	66.79	139.19
Organic efficiency (%)	19.57	5.12	25.81
Targeted yield equations			
FN = 5.78T — 1.47 × STVN — 0.55 ×M			
FP = 0.97 T — 1.48 × STVP — 0.08 × M			
FK = 2.03 T —0.54 × STVK — 0.19 × M			

Table 3.13. Physical and chemical properties changes in the rhizosphere soils of different crops

Crop	Clay (%)	Silt (%)	Sand (%)	pH (1:2.5)	EC (dSm^{-1})	SOC (g kg^{-1})	N_a (kg ha^{-1})	P_a (kg ha^{-1})	K_a (kg ha^{-1})	Zn (mg kg^{-1})	Cu (mg kg^{-1})	Fe (mg kg^{-1})	Mn (mg kg^{-1})
Pulses	25.84	52.80	21.36	7.69	0.26	0.73	273.66	19.97	517.48	2.25	1.47	23.20	20.00
Mustard	24.60	55.23	20.17	7.74	0.24	0.71	278.33	21.13	524.80	2.18	1.37	24.05	20.03
Wheat	33.93	44.41	21.65	8.03	0.44	0.63	243.64	36.99	239.94	0.99	1.74	19.94	4.92
Potato	29.44	46.23	24.33	7.80	0.76	0.55	302.67	39.06	312.65	2.12	3.81	36.74	18.04
Average	28.45	49.67	21.88	7.82	0.42	0.66	274.58	29.29	398.72	1.89	2.10	25.98	15.75
SD	3.63	4.48	1.52	0.13	0.21	0.08	20.98	8.78	125.12	0.52	1.00	6.40	6.30
SE	2.10	2.59	0.88	0.08	0.12	0.05	12.13	5.08	72.32	0.30	0.58	3.70	3.64

Note: SD- standard deviations, SE- standard error

Table 3.14. Microbial activity,MBC, MBN, qCO_2 and enzymatic activities changes in the rhizosphere soils of different crops

Crop	TCB ($\times10^6$cfu g^{-1})	TCA ($\times10^5$cfu g^{-1})	TCF ($\times10^4$cfu g^{-1})	AZO ($\times10^6$cfu g^{-1})	MBC (µg C g^{-1} soil)	MBN (mgNH_4-N$kg^{-1}day^{-1}$)	qCO_2 (µg CO_2-C g^{-1})	DHA (µg TPTg^{-1}hr^{-1})	FDHA	ACP (µg PNF g^{-1}	ALP (hr^{-1})
Pulses	39.85	9.53	51.76	130.34	370.03	3.12	2.45	2.80	47.74	478.1	310.1
Mustard	22.84	9.40	37.00	25.56	317.73	2.72	2.42	2.41	39.87	466.4	324.5
Wheat	11.09	1.52	4.58	9.72	156.13	1.59	2.47	1.34	43.06	470.6	301.9
Potato	2.28	1.75	19.16	21.99	126.56	2.81	2.40	1.51	39.81	488.5	387.0
Average	19.02	5.55	28.12	46.90	242.56	2.56	2.44	2.02	42.62	475.9	330.9
SD	14.07	3.92	17.83	48.53	103.53	0.58	0.02	0.61	3.24	8.39	33.4
SE	8.13	2.27	10.31	28.03	59.84	0.33	0.01	0.35	1.87	4.85	19.3

Note; SD- standard deviations, SE- standard error

plant growth promoting rhizobacterial activity. Out of forty, only five strains of *Pseudomonas viz.*, PS-8, PS-21, PS-22, PS-25 and PS-35 not showing HCN activity whereas PS-4, PS-9, PS-17, PS-19 and PS-26 showed the highest HCN activity. The highest ammonia production was found only in eight strains of *Pseudomonasspp. viz.*, PS-16, PS-19, PS-20, PS-21, PS-22 and PS-23 while as seven strains (PS-6, PS-11, PS-30, PS-31, PS-37, PS-39 and PS-40) did not show ammonia production activity. All the strains of *Pseudomonas* spp. exhibited indole acetic acid production but the highest IAA was recorded with PS-26 followed by PS-24, PS-22 and PS-29. Phoephate solubilizing activity was the highest in the strains of PS-17 followed by PS-19, PS-34 and PS-40. Out of forty, only four strains of *Pseudomonas viz.*, PS-8, PS-27, PS-39 and PS-40 were not exhibited catalase activity whereas remaining strains showing medium to high catalase activity. Overall, strain PS-19 showed the highest PGPR activities followed by PS-24, PS-18 and PS-9.

Response of sugarcane crop to different plant nutrients in varied agro-ecological situations

Field experiment was ratooned during spring (1st week of March) of 2015. The soils of the experimental field was sandy loam (*Inceptisol*), neutral in reaction (pH 7.45), initially soil was medium in available nitrogen (225.8 kg/ha), low in organic carbon (0.40%), phosphorus (17.24 kg P_2O_5/ha) and potassium (191.00 kg K_2O/ha) contents. The experiment was continued with mid late maturing sugarcane variety CoSe 92423 in randomized block design with fourteen treatment of nutrient combinations for its residual effect. The treatments were T_1: Control (no fertilizer), T_2: N (150 kg/ha), T_3 : NP (150:60 kg/ha), T_4 : NPK (recommended dose 150:60:60 kg/ha),T_5 : NPK+S (150:60:60+S @ 40 kg/ha), T_6 : NPK+Zn (150:60:60+$ZnSO_4$ @ 25 kg/ha), T_7: NPK+Fe (150:60:60 + $FeSO_4$ @ 10 kg/ha), T_8: NPK+Mn (150:60:60 + $MnSO_4$ @ 5 kg/ha), T_9 : NPK+S+Zn (150:60:60 + S 40 + $ZnSO_4$ 25 kg/ha), T_{10} : NPK+S+Zn +Fe (150:60:60 + S 40+ $ZnSO_4$ 25+ $FeSO_4$ @ 10 kg/ha), T_{11} : NPK+S+Zn+Fe+Mn (150:60:60+S 40+$ZnSO_4$ 25+ $FeSO_4$10+ $MnSO_4$ 5 kg/ha), T_{12}:Soil test based fertilizer application (STF- NPK: 187.5+ 75+75 kg/ha), T_{13}: only FYM @ 20 t/ha and T_{14}: Soil test crop response (STCR-IISR -NPK:142:110:240 kg/ha).

The shoot count at 90 days after initiation was uniform in all the treatments, except FYM was superior. Results revealed that significantly higher number of millable canes (NMC 94.60 k/ha), cane yield (75.05 t/ha) were recorded with NPK+S (T_5) and NPK+S+Zn (T_9) with NMC (93.17 k/ha) and cane yield (75.73 t/ha) over the control (NMC 83.17 k/ha and cane yield 58.77 t/ha, respectively), which was 11 and 22% higher in both the treatments (Table 3.15).

Similarly, FYM (T_{13}) recorded higher cane yield (73.21 t/ha) followed by the treatment NPK+Zn (T_6) with cane yield 72.85 t/ha; NPK+S+Zn+Fe+Mn (T_{11}) cane yield 71.59 t/ha and Soil test crop response (STCR-IISR:T_{14}) with cane yield 71.13 t/ha as compared to other treatments, however, yield *per se* were at par. Cane juice quality parameters, *viz.*, Brix, sucrose and purity were not found to be significant among any of the nutrients applied.

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

Rationalizing irrigation water use through optimizing field application parameters

Field experiment was initiated on succeeding ratoon to optimize various irrigation application parameter *viz.*, furrow length, discharge rate and cut off length for furrow irrigation system. The experimental results unveiled that significantly the highest shoot count (161.3 thousand/ha at 150 DAP), number of millable canes (123.9 thousand/ha), cane yield (59.9 t/ha) and sugar yield (8.82 t/ha) were recorded with the discharge of 10 lps+85% cut off length. The combination of 10 lps+85% cut off has also resulted in the highest IWUE of 1755.9 and 2194.6 kg/ha-cm in 50 m and 75 m furrow length, respectively. This combination has also saved 40.9%

Table 3.15. Effect of plant nutrient combinations on growth, cane yield and juice quality of sugarcane

Treatment	Shoot Count at 90 DAR (k/ha)	NMC (k/ha)	Cane yield (t/ha)	Juice quality parameters at harvest		
				°Brix	Sucrose (%)	Purity (%)
T_1 Control	106.88	83.17	58.77	20.09	17.31	86.09
T_2 N	107.73	86.98	62.37	20.41	17.87	87.51
T_3 NP	109.84	87.14	65.14	19.54	16.72	85.56
T_4 NPK	113.54	87.61	70.15	18.94	16.23	85.62
T_5 NPKS	116.19	94.60	75.05	19.55	16.95	86.71
T_6 NPKZn	119.37	88.88	72.85	19.49	17.03	87.35
T_7 NPKFe	126.56	84.12	65.89	19.64	17.01	86.58
T_8 NPKMn	109.31	83.96	69.55	18.83	15.93	84.62
T_9 NPKSZn	118.31	93.17	75.73	20.06	17.68	87.93
T_{10} NPKSZnFe	127.09	88.25	70.21	19.50	16.94	86.80
T_{11} NPKSZnFeMn	110.36	88.57	71.59	18.92	16.29	86.21
T_{12} STF	110.37	88.88	70.89	19.89	16.98	85.36
T_{13} FYM 20 t/ ha	127.09	89.84	73.21	19.15	16.54	86.40
T_{14} STCR-IISR	114.07	88.89	71.13	18.88	16.29	86.19
CD (5%)	NS	NS	15.88	NS	NS	NS

Note : DAR: Days after ratooning

of total irrigation water as compared to border irrigation method (general farmers practice). A strong correlation was observed between the total water used and yield. However, yield *per se* was not significantly different between the check (border irrigation- 85% cut off length) and highly water efficient system (10 lps+85% cut off). Juice quality parameters *viz.*, brix pol and purity were not found to be significant among any treatments.

The effect of different amount of discharge and cut off length was also measured on moisture flow pattern (Fig 3.1 & 3.2). It showed a clear downward flow of water in all the furrow irrigation combination methods with required water availability at tail end region. Treatment of furrow-10 lps+85% cut off length and furrow-10 lps+75% cut off length showed the optimum discharge rate to move water towards tail end. Therefore, it may be apprehend that even though cut at 85% or 75% furrow length, discharge of 10 lps is found to be efficient to soak the water at tail end of the field. Border irrigation method has shown a total irregular pattern of flow with ups and downs in head, middle and tail region along different depths resulting in inefficiency of water use.

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

Third ratoon crop was initiated during third week of February, 2015 and the crop was harvested in the third week of January, 2016. The highest sugarcane yield of 111.42 t/ha was observed when sugarcane was drip fertigated with recommended dose of nitrogen and water equivalent to 125% pan

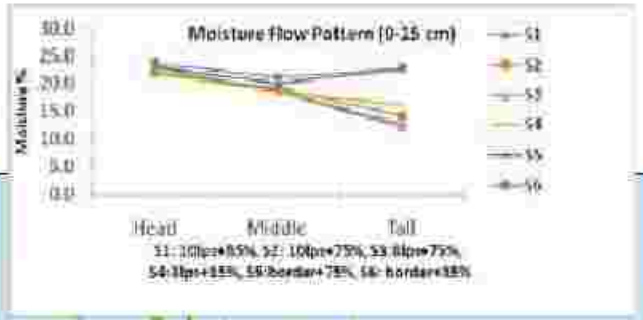


Fig 3.1. Moisture flow pattern observed in soil depth 0-15 cm

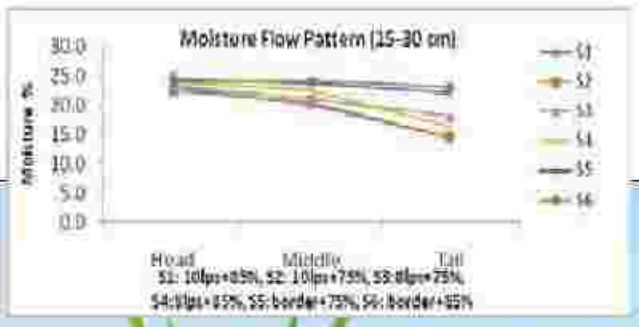


Fig 3.2. Moisture flow pattern observed in soil depth 15-30 cm

Table 3.16. Irrigation water use efficiency (kg/ha-cm)

Nitrogen/Irrigation	Irrigation water applied (ha-cm)	Nitrogen application rate			
		N_1 = 100% RDN	N_2 = 75% RDN	N_3 = 50% RDN	Average
I_1= Sub Surface Drip at 75% PE	43.0	2265.5	2168.7	2150.2	2194.8
I_2 = Sub Surface Drip at 100% PE	57.0	1806.3	1788.1	1755.1	1783.2
I_3 = Sub Surface Drip at 125% PE	72.5	1536.8	1476.5	1465.0	1492.8
I_4=Farmers' practice surface irrigation	96.0	840.8	764.0	714.4	773.1
Average		1612.4	1549.3	1521.2	22.7
SE (Irrigation)					72.2
CD (Irrigation)					19.7
SE (Nitrogen)					84.6
CD (Nitrogen)					22.7
SE (Irrigation x Nitrogen)					NS
CD (Irrigation x Nitrogen)					

Note : RDN is recommended dose of N.

Table 3.17. Sugarcane yield (t/ha) as influenced by different fertigation schedule and micro-irrigations techniques

Nitrogen/Irrigation	Nitrogen application rate			
	N_1 = 100% RDN	N_2 = 75% RDN	N_3 = 50% RDN	Average
I_1= Sub Surface Drip at 75% PE	97.42	93.25	92.46	94.38
I_2 = Sub Surface Drip at 100% PE	102.96	101.92	100.04	101.64
I_3 = Sub Surface Drip at 125% PE	111.42	107.05	106.21	108.23
I_4=Farmers pratice surface irrigation	80.71	73.34	68.59	74.21
Average	98.13	93.89	91.83	
SE (Irrigation)				1.38
CD (Irrigation)				4.38
SE (Nitrogen)				1.19
CD (Nitrogen)				5.13
SE (Irrigation x Nitrogen)				1.38
CD (Irrigation x Nitrogen)				NS

Note : RDN is recommended dose of N.

evaporation (Table 3.16 & 3.17). However, irrigation water use efficiency (IWUE) was the highest at 2265.5 kg/ha-cm when fertigation with recommended dose of nitrogen was done and the amount of irrigation water was kept at 75 per cent of pan evaporation. The sugarcane yield and IWUE were influenced by doses of nitrogen in fertigation treatments but the influence of nitrogen on sugarcane yield and irrigation water use efficiency was more distinctive in surface irrigation treatment. With surface irrigation, the mean sugarcane yield and IWUE were 74.21 t/ha and 773.1 kg/ha-cm, respectively. However, irrigation treatments did not influence the cane juice quality parameters significantly.

Assessment of impact of climate change on productivity and quality of sugarcane and opportunities of adaptation

Relationship of temperature and relative humidity during maturity phase with sugar recovery

Relationship of temperature and relative humidity during maturity phase with sugar recovery

in sugarcane was worked out from the data obtained from R.B.N.S.Sugar Mills Limited, Laksar, Haridwar, Uttarakhand for the years 2009-10, 2011-12, 2012-13, 2013-14 and 2014-15. Sugar recovery was influenced by the variations of temperatures and relative humidity during maturity phase. It was observed that increase in T_{max} (> 21 °C), T_{min} (> 8.4 °C) and relative humidity reduced sugar recovery, however, a reverse trend was observed with respect to range of temperature.

Relationship of temperature with NMC, cane yield and sucrose % juice in plant and ratoon crops in North-Western Zone of sugarcane cultivation

Relationship of temperature with NMC, cane yield and sucrose % juice in plant and ratoon crops in North-Western Zone of sugarcane cultivation was studied using the data generated in the All India Coordinated Research project (Sugarcane) during the years 2006-07, 2007-08, 2008-09, 2009-10, 2011-12, 2012-13 and 2013-14 at various centres in this Zone for plant and ratoon crops in early ripening (ERVs) and mid-late ripening (MRVs) varieties.

- Response of plant and ratoon crops of ERVs and MRVs to increasing a range of temperatures (TR) differed. For NMC, in ERVs increasing TR caused no difference in plant crop but decreased it in ratoon crops. In plant crop of MRVs increasing TR decreased NMC but it increased in their ratoon crops. Sugarcane yield increased with increasing TR in plant as well as ratoon crops in ERVs, but in the MRVs, however, there was a slight decrease in plant crop and increase in the ratoon crops. For sucrose % juice, in ERVs, there was no change in response to increasing TR in plant crop but in ratoon, it registered a slight increase. In MRVs, increasing TR slightly increased sucrose % juice in plant crop but in their ratoon crops, it registered a slight decrease.
- Increase in T_{max} and T_{min} caused no difference in NMC in plant and ratoon crops of ERVs but in MRVs, it registered some increase in both plant and ratoon crops. For cane yield, with increasing T_{max} and T_{min} registered no change in plant crop of the ERVs but in the respective ratoon crop, it increased. In MRVs, both in plant and ratoon crops, increasing T_{max} increased cane yield but increasing T_{min} either caused a slight increase (in plant crop) or no change (in ratoon crop). For sucrose with increasing T_{max} and T_{min} there was some decrease in plant as well as ratoon crops of both ERVs and MRVs.
- The InfoCrop-Sugarcane model developed earlier with the help of the Centre for Environmental Sciences and Climate Resilient Agriculture, ICAR-IARI, New Delhi was validated using the data obtained for various locations in Peninsular zone of sugarcane cultivation in India. Simulated and observed data of phenology and cane yield matched to a fairly good degree.

4

Management of insect-pests and diseases

Survey and surveillance of diseases of sugarcane in sub tropical India

A survey was conducted for monitoring the occurrence of insect pests and disease in Uttar Pradesh (Command areas of DSCL Group, Balrampur Chini mill Group, Bajaj Hindustan Group, Birla Group and Seksaria Biswan Chini Mill, Biswan, Sitapur); in Bihar, (Command areas of Harinagar Sugar Mill, Hasanpur Sugar Mill) and in Maharashtra (Command areas of Padamshri Dr. V.K. Patil Sakhar Karkhana, Pravaranagar) were surveyed.

In the survey of diseases of sugarcane, incidence of red rot was noticed mostly in old sugarcane varieties *i.e.*, CoLk 8102, CoS 8436, CoS 91269, and CoJ 85. Localized incidence of red rot was noticed in two popular varieties *viz.*, Co 0238, (at Biswan) and CoLk 94184 (at Gularia). In general, incidence of red rot was low hardly exceeding 1%. However, in some fields of CoLk 8102 and CoS 8436, the incidence was to the tune of 20%. Sporadic incidence of smut was observed in CoSe 92423 and Co 0238. Incidence of grassy shoot disease (GSD) was noticed in most of the fields surveyed. However, incidence was within the 1-2%. In some locations, higher incidence of GSD was noticed in CoS 91269, (5-10%). The incidence of minor diseases like Pokkah Boeng is increasing substantially and it is mostly affecting the early sugarcane variety Co 0238. In some fields, Pokkah Boeng incidence was more than 30%. Stray incidence of leaf scald was also noticed in Co 0238.

The occurrence of yellow leaf disease (YLD) was recorded in 65 sugarcane genotypes at ICAR-IISR farm. The disease incidence was ranged from 19.04 to 52.88% in 13 genotypes *viz.*, Co 11027, Co 12028, CoH 11262, CoPb 11212, CoPb 11211, CoPb 11182, CoPb 12112, CoPant 12223, CoPant 12222, CoPant 12226, CoS 11232, CoS 12231 and LG 077571. While, no visual symptoms were recorded on six genotypes *viz.*, Co 11036, CoH 12263, CoLk 12202, CoPb 10181, CoPb samples were collected from 14 sugarcane varieties, including Khakai, Baragua, Co 0238, CoJ 64, CoPant 97222, CoS 09232, CoLk 9709, BO 91, CoLk 94184, Co 1148, CoS 767, CoLk 8102, Co 05011 and CoLk 07201. Incidence of disease was 10 to 40%.

To detect the association of phytoplasma with YLD, all the symptomatic samples were subjected to genomic DNA isolation using Qiagen gDNA mini kit followed by nested PCR using the universal primers for phytoplasma detection. The PCR resulted approximately 1.8 kb size amplicons (Fig. 4.1a) from the first round PCR while approximately 1.2 kb size amplicons (Fig. 4.1b) from second round PCR, this confirms the detection of phytoplasma with YLD affected sugarcane samples. To detect the SCYLV, the total RNA was extracted using the Qiagen RNA isolation mini kit followed by RT-PCR using SCYLV specific primers. RT-PCR revealed no specific amplification. Hence, the efforts are being made in designing of new sets of primers and optimization of the PCR conditions.

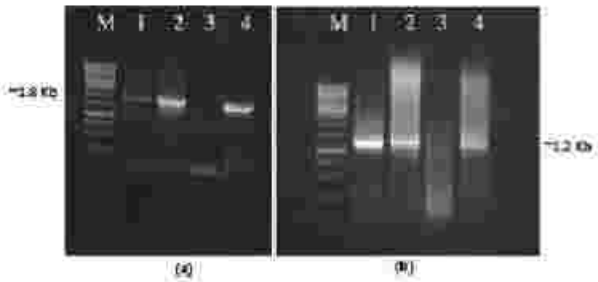


Fig. 4.1. 1.5% agarose gel electrophoresis showing amplification of Sugarcane yellow leaf phytoplasma using nested PCR as: (a) first round PCR amplification of approximately 1.8 kb from Co 0238 (Lanes: 1 & 2) and from CoLk 94184 (Lanes: 3 & 4) and second round PCR amplification of approximately 1.2 kb from Co 0238 (Lanes: 1 & 2) and from CoLk 94184 (Lanes: 3 & 4).

Besides, the severe infestation of the thrips (1.4-6.5 thrips/plant) was recorded on 12 sugarcane genotypes *viz.*, CoLk 7201, Co 0975, Co 1148, Co 0238, CoLk 8102, CoLk 94184, CoJ 64, CoPant 97222, CoS

different serial heat treatments for consecutive three days, one standard MHAT for one day and planted with two controls (C_1. Diseased seed cane; C_2. Healthy seed cane) in two locations (one in open field and one in net house). Sum total of six observations have been recorded each after 50 days intervals on visual basis. Out of these visual observations, two molecular detections had also been performed (one at the 150 days old crop and another at 250 days old crop) from both the locations, results revealed that none of the treatments along with control was found infected with the YLD up to the crop age of 150 days. Appearance of YLD symptoms was noticed first at 200 days old crop with two plants of T_3; five plants of T_4 and nine plants in C_1. At the age of 250 days old crop, T_3, T_4 and C_1 recorded YLD infection in visual observation as well as molecular detection. Rest of the treatments were found free from the YLD infections. At the crop age of 300 days, all the treatments were found infected with the Yellow Leaf Disease except T_1. Out of all the five treatments, T_1 (Serial thermotherapy of two hours through MHAT at 50°C for three consecutive days) was found effective for crop plant to overcome the infection of YLD from the seed cane.

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

Sixty five germplasm/genotypes were screened against red rot (Cf 08 and Cf 09), smut and wilt.

Red rot

Out of these, nine genotypes *viz.*, II-4-01, II-77-09, II-23-01, II-75-06, II-22-10, LG 11602, III-39-03, II-84-10 and II-23-04 were found highly susceptible (HS) to both the pathotypes (Cf 08 and Cf 09). One genotype LG 11604 was found susceptible (S) to both the phenotypes (Cf 08 and Cf 09). One genotype LG 11665 was rated as resistant (R) to pathotype Cf 08 and moderately resistant (MR) to pathotype Cf 09. Two genotypes *viz.*, II-71-01 and II-68-01 were found highly susceptible (HS) to the pathotypes Cf 08 and susceptible (S) to phenotype Cf 09 of red rot. Three genotypes *viz.*, LG 11663, II-15-03 and I-87-10 were found highly susceptible (HS) to pathotype Cf 08 and moderately resistant (MR) to pathotype Cf 09. Two 01were found moderately resistant (MR) to pathotype Cf 08 and highly susceptible (HS) to pathotype Cf 09. Two genotypes *viz.*, II-74-07 and II-31-04 were found moderately resistant (MR) to pathotype Cf 08 and susceptible (S) to pathotype Cf 09. Five genotypes *viz.*, II-02-07, LG 12020, LG 12028, LG 12075 and LG 12005 were found moderately resistant (MR) to pathotype Cf 08 and moderately susceptible (MS) to pathotype Cf 09 of red rot. The remaining genotypes *viz.*, LG 12032, LG 12082, LG 11167, I-67-05, I-08-04, LG 11626, LG 12081, LG 12037, LG 11645, LG 11653, LG 11633, LG 11650, LG 11627, LG 12027, LG 08425, LG 08422, LG 07451, LG 05447, LG 07584, LG 07554, LG 07444, I-05-09, II-03-16, LG 11669, LG 12022, LG 12044, LG 12090 and V-100-04 were found moderately resistant (MR) to both the phenotypes (Cf 08 and Cf 09)

Smut

The incidence of smut was recorded for the above mentioned genotypes. Out of sixty five genotypes tested by following standard protocol, twenty five genotypes viz., II-77-09, II-22-10, I-101-09, I-08-04, II-31-04, II-03-16, I-05-09, II-02-07, LG 11658, LG 11637, LG 11633, LG 12005, LG 08422, LG 12040, LG 12081, LG 12037, LG 11167, LG 08425, LG 07443, LG 07461, LG 12075, LG 07444, LG 11602, LG 11604 and LG 11650 were rated as susceptible (S) to smut disease.

Wilt

Out of sixty five genotypes, twenty three genotypes *viz.*, LG 12082, LG 12084, I-67-05, I-08-04, II-75-06, LG 12081, LG 12037, LG 12040, II-68-01, LG 11633, LG 12027, LG 12020, LG 12028, I-05-09, II-03-16, LG 12044, LG 12090, V-89-07, II-81-06, III-48-07, I-11-09, III-12-08 and IV-73-01 were found susceptible (S) to wilt under natural conditions.

Trichoderma based red rot management system

Enhancing efficacy of *Trichoderma* based red rot management system

Studies were carried out to isolate, characterize and identify potent isolates of *Trichoderma* from different sugarcane agro-ecosystems and to assess the role of various antifungal enzymes/secondary metabolites produced by *Trichoderma* in the inhibition

comparable to the previously identified promising isolates STr-83 and STr-108. The potential of secondary metabolites of three promising *Trichoderma* isolates for management of red rot was further evaluated in a field experiment. Three bud setts of variety Co 1148, previously inoculated with *C. falcatum* (Cf 01) by sett-dip method (10^6spores ml^{-1}), were treated with culture filtrates of *Trichoderma* isolates and planted along with suitable controls and data on disease development, growth parameters and yield was recorded. The highest reduction in *C. falcatum* induced bud mortality relative to control was observed in treatment with metabolites of isolates STr-83 (43.6%) and STr-108 (40.4%). STr-83 metabolite treatment also exhibited significantly higher yield (60.3 t ha^{-1}) as compared to control (45 t ha^{-1}). Preliminary studies were carried out to study the potential of two high cellulase producing *Trichoderma* isolates (STR-83 & STr-108) for trash decomposition and its impact on soil nutrient status. The results revealed that sprays of *Trichoderma* isolates (STr-83 and STr-108) over the trash mulch resulted in an increase in the soil organic carbon status, available nitrogen, P_2O_5 and K_2O as compared to soils with trash mulch alone or without trash.

To assess the role of induced systemic resistance during the three way interaction between sugarcane-*Trichoderma*- *C. falcatum;* the biochemical changes associated with this interaction were assessed in the field experiment. The total phenol content, defense related enzymes *viz.*, phenylalanine ammonia lyase (PAL), tyrosine ammonia lyase (TAL), super oxide dismutase (SOD), polyphenol oxidase (PPO), chitinase and β-1,3 glucamase as well as changes in the pattern of enzymatic activities were monitored in *Trichoderma* metabolite treated as well as control plants at different crop stages. Considerable increase in total phenol contents as well as all defense related enzymes was recorded in all the three *Trichoderma* treatments as compared to pathogen inoculated and uninoculated control. However, the pathogen inoculated control showed higher phenol content than uninoculated control. In case of pathogen inoculated and uninoculated control, the phenolic contents showed increasing trend upto 135 days followed by a sharp decline after 135 days, while in case of

planting was higher by 24.7% and 106%; PPO activity by 113% and 161%, PAL activity by 112% and 162%; TAL activity by 118% and 206%; β-1,3 glucanase activity by 83% and 160%; chitinase activity by 291% and 546% and SOD activity by 31% and 78%, respectively.

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

A field trial was conducted with sugarcane variety CoLk 94184 to find out the suitable delivery system for the application of *Trichoderma* sp. to sugarcane. Farmyard manure (FYM) based *Trichoderma* culture was applied by three methods *viz.*, furrow application @ 220 kg/ha before planting, two gm *Trichoderma* multiplied culture (TMC) per poly bag and two gm TMC per settling raised by spaced transplanting technique (STP) method at the time of transplanting. No *Trichoderma* was applied in control treatment. The settlings raised in poly bags and STP gave significantly higher cane yield when treated with *Trichoderma* sp. as compared to untreated control whereas in conventional method of planting, cane yield was non-significant.

Management of top borer

Mechanism of resistance against top borer of sugarcane

A field experiment was conducted to establish correlation between plant characters and top borer incidence. Nine sugarcane varieties (CoS 94257, CoSe 92423, CoPant 97222, CoS 96268, CoS 767, Co 0238, CoLk 94184, CoJ 64 and CoLk 8102 were taken. Observations were recorded on physical characters (length, width of leaf, length and loosely/tightly attachment of leaf sheath) and incidence of top borer brood wise.

Incidence of top borer III brood was 15.98, 3.01, 12.63, 7.57, 15.46, 11.11, 15.09, 5.06 and 13.75 per cent and of IV brood was 26.07, 17.55, 38.91, 28.17, 16.24, 40.95, 16.47, 20.51 and 13.79 in CoLk 810, CoJ 64, Co 0238, CoLk 94184, CoSe 92423, CoPant 97222, CoS 767, CoS 94257, CoS 96268, respectively. Incidence of top borer (III brood) was less than 10 per cent in CoJ 64, CoLk 94184 and CoS 94257. The width of mid rib of all

multiplication of parasitoids. Stalk pieces of sugarcane (3-4 inches) split longitudinally into two equal halves with a central tunnel was made. One or two vertical holes (1.5 mm in dia.) were drilled from the rind towards the tunnel. Stored top borer larvae were placed in these tunnels (one per tunnel). To prevent the escape of larvae, the stalk pieces were wrapped with parafilm. These were kept in glass jars with muslin covering. In each jar, one pair of *Isotima javensis* or one pair of *Rhaconotus scirpophagae* (after 24 hr emergence) was placed. Honey solution was provided in cotton swabs as food for adult parasitoids. The parasitisation of top borer larvae by *Isotima javensis* and *Rhaconotus scirpophagae* was 26.43% and 34.05%, respectively. The female biased sex ratio was observed in *Rhaconotus*.

Containment of major insect-pests of sugarcane through habitat modifications

Effect of coriander, mustard, marigold, tomato, brinjal, *jowar* and maize as intercrops on containment of insect pests of sugarcane (mainly borers) and on abundance of natural bio-agents was studied.

The incidence of top borer (I brood) ranged from 4.36%-8.36% along with various trap crops in comparison to control (15.43%).

The incidence of top borer (I brood) was 4.36%, 5.64%, 6.48%, 7.93% and 9.23% in plots received marigold, coriander, tomato, brinjal and mustard as intercrops, respectively as against 15.43% in sole sugarcane crop (untreated control). The minimum incidence of top borer (II brood) (7.07%) was in plots raised with marigold in comparison to sole sugarcane (18.71%).

The incidence of top borer (III brood) was low along with various trap crops (6.33%-16.07%) as compared to control (19.81%).

The incidence of top borer (IV brood) was 12.21% in plots raised with *jowar* as against control (33.52%). The incidence of top borer (V brood) ranged from 10.44% to 13.48% in plots along with maize, tomato, brinjal and *jowar* as compared to 23.48% in control.

The incidence of internode borer ranged from 9.82 to 16.82% along with various trap crops in comparison to control (29.59%). The minimum incidence was observed in plots along with *jowar* and maize.

Population of natural enemies of top borer in different habitat

The parasitisation of eggs of top borer (I brood) by *Trichogramma chilonis* and *Telenomus* sp. ranged from 18.53 to 33.64% along with marigold, coriander and tomato.

The extent of parasitisation of top borer larvae (III brood) by larval parasitoids (*Rhaconotus scirpophagae, Isotima javensis* and *Stenobracon nicevillei*) ranged from 31.82 to 48.61% along with various trap crops (Fig.4.2). The maximum parasitisation was observed in plots along with maize (48.61%), *jowar* (42.53%), brinjal & marigold (34%) and tomato (31.8%). The parasitisation of top borer larvae (IV brood) by three parasitoids was observed maximum in *jowar* (43%) followed by maize (41.76%) as compared to control (25%). The maximum parasitisation occurred in III & IV brood, the time when the brood infestation remains generally very high. The synchronisation of parasitisation with the availability of the borer larvae in the fields at this time helped a good deal in keeping the pest under check.

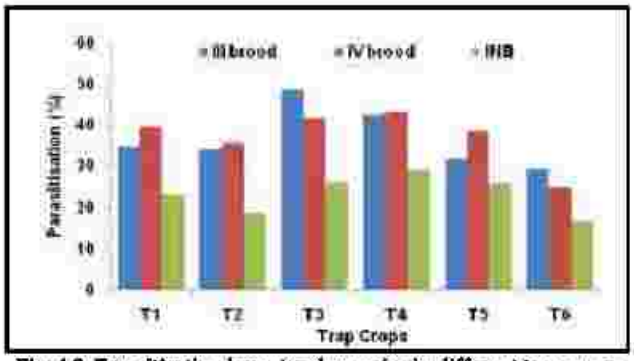


Fig. 4.2. Parasitisation by natural enemies in different trap crops

The maximum parasitisation by larval parasitoid, *Cotesia flavipes* ranged from 18.71 to 29.00% in various trap crops as compared to control (16.81%). *Cotesia flavipes* is more active in the field (along with *jowar* and maize) for its parasitisation which result a reduction in the incidence of internode borer.

Semio-chemicals for the management of sugarcane top borer

Experiment was planted with top borer susceptible sugarcane varieties (CoLk 8102, Co 0238, CoJ 64) in February, 2015. Egg and larvae of top borer were extracted in n hexane and sprayed on the crop before commencement of third brood.

CoLk 8102

- Incidence of top borer in plots treated with egg wash was 58.18 % (cumulative III and IV brood) and parasitisation by *Rhaconotus* sp. and *Isotima javensis* was 10.00 and 13.33 per cent, respectively.

- Incidence of top borer in plots treated with larvae wash was 56.25% (cumulative III and IV brood) and parasitisation by larval parasitisation *Rhaconotus* sp. and *Isotima javensis* was 6.67 and 16.67 per cent, respectively.
- Incidence in untreated control was 42.18% (cumulative III and IV brood)and the parasitisation by *Rhaconotus* sp. and *Isotima javensis* was 6.67 per cent.

Co 0238

- Incidence of top borer in plots treated with egg wash was 40.06% (cumulative III and IV brood) and egg parasitisation by *Telenomus beneficiens* was not affected but the parasitisation by *Rhaconotus* sp., *Isotima javensis* and Stenobracon sp. was 10.00, 16.67 and 3.33 per cent, respectively.
- Incidence of top borer in plots treated with larvae wash was 61.51% (cumulative III and IV brood) and egg parasitisation by *Rhaconotus* sp., *Isotima javensis* and *Stenobracon* sp. was 6.67, 13.33 and 3.33 per cent, respectively.
- Incidence in untreated control was 51.81% (cumulative III and IV brood) and parasitisation by *Rhaconotus* sp., *Isotima javensis* and *Stenobracon* sp. was 6.67, 10.00 per cent, respectively and no parasitisation by *Stenobracon* sp. was observed.

CoJ 64

- Incidence of top borer in plots treated with egg wash was 38.93% (cumulative III and IV brood) and egg parasitisation by *Telenomus beneficiens* was not affected but the parasitisation by *Rhaconotus* sp. and *Isotima javensis* was 3.33 and 20.00 per cent, respectively.
- Incidence of top borer in plots treated with larvae wash was 40.93% (cumulative III and IV brood) and egg parasitisation by *Rhaconotus* sp. and *Isotima javensis* was 13.33 and 6.67 per cent, respectively.
- Incidence in untreated control was 38.70% (cumulative III and IV brood) and parasitisation by *Rhaconotus* sp. and *Isotima javensis* was 10.00 and 3.33 per cent, respectively and no parasitisation by *Stenobracon* sp. was observed.

Impact of climate change on sugarcane insect pests dynamics and behaviour

Based on the long term data on incidence of top borer (II, III and IV brood), internode borer and stalk borer and weather parameters (maximum - minimum temperature (°C), sunshine hours, relative humidity at 07 hrs and 14 hrs, rainfall (mm), number of rainy days, wind velocity (km hr^{-1}) and duration of sunshine (hrs day^{-1}) were identified as the important weather factors responsible for buildup of incidence in different borers by multivariate data analysis technique. Models were also developed for each borer to study the impact of important factors on incidence of borers and to forecast occurrence of insect pest during the month.

The model was developed to forecast the incidence of top borer (II brood) during the month of February is [(- 4.3+2.14 maximum temperature -4.14, minimum temperature +0.177, rainfall (R^2= 63.7%)].

The model for prediction of incidence of III brood of top borer is [(7.77 - 0.147 rainfall + 5.00 number of rainy days+ 2.03 duration of sunshine (R^2= 64.71)].

The model for prediction of incidence of top borer (IV brood) is [(-95.0+14.0 maximum temperature–4.44 relative humidity + 6.81 rainy days (R^2 = 64.2)].

$$RTD = \frac{\text{Maximum temperature - Mimmum temperature}}{\text{Maximum temperature}} \times 100$$

Relative temperature disparity (RTD) index calculated to study the impact of temperature on top borer incidence was as follows:

If RTD is > 55%, then the incidence of II brood of top borer is > 10% in February. As RTD decreases in between 20 to 25%, then top borer incidence increases to 20% in III brood and 26% in IV brood. As rainfall increases from 33 mm to 164 mm, rainy days increase from 2 to 7 and relative humidity increase from 43 to 67% at 14 hrs then the top borer incidence increases from 9% in second brood to 26% in IV brood (Table 4.1).

The regression equation for forecasting of incidence of internode is [(- 652.0+8.72 maximum temperature+5.34 relative humidity at 07 hrs -1.33 relative humidity at 14 hrs (R^2=83.4%)].

The model for forecasting the stalk borer is [(132-5.8 minimum temperature +0.159 relative humidity at 14 hrs +3.55 duration of sunshine (R^2= 88.5%)].

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

Two major activities going on at ICAR-IISR, Biological Control Centre, Pravaranagar, Maharashtra on this aspect are as follows:

i. **Mass multiplication and field colonization of *Trichogramma chilonis* and distribution against early shoot borers**

Table 4.1. Average value of weather parameters, RTD and top borer incidence for ten years

Brood of top borer	% incidence	Month	Temperature (°C)		RH (%)		Rainfall (mm)	Rainy days (No.)	Wind velocity (km/hr)	Duration of sunshine (hr/day)	Relative temperature disparity - RTD(%)
			Max.	Min.	07 Hr	14 Hr					
II	9.467	February	25.25	11.15	88.6	43.00	32.771	2.301	3.53	4.37	55.77
III	20.5	June	37.36	26.65	71.82	48.78	121.95	4.802	3.65	3.27	28.37
IV	25.988	September	33.52	23.4	88.7	66.5	164.3	6.9	2.46	4.17	29.84

Mass multiplication of *Trichogramma chilonis* (Tricho cards) was done at ICAR-IISR Biological Control Centre, Pravaranagar, Maharashtra. Mass multiplication of *Trichogramma chilonis* Ishii was done on eggs of rice moth, *Corcyra cephalonica* Stanint in the laboratory. Trichocards were prepared from UV treated host eggs. *Trichogramma chilonis* was released @ 50,000 wasps/ha at 10 intervals against shoot borer and internode borer. A significant reduction in incidence of early shoot borer has been recorded as against unreleased control.

ii. Survey of insect pests of sugarcane

In the month of January 2016, a team of scientists of ICAR-IISR, Lucknow visited the command area of PDVVPSSK Ltd., Sugar Factory farm, Pravaranagar. The incidence of shoot borer was 2.5 to 12.5 per cent while the incidence of scale insect, *Melasapis glomerata* in *Adsali* crop was low. Incidence of internode borer in CoM 0265 was in traces.

AICRP (S)

Identification of pathotypes in red rot pathogen

Twenty new isolates *i.e.*, six isolates from CoLk 8102 (IR-80, IR-81, IR-82, IR-83, IR-84 and IR-85); five isolates from CoLk 94184 (IR-88, IR-89, IR-90, IR-91 and IR-92); three isolates from CoS 8436 (IR 75, IR 78 and IR 79); two isolates from Co 0238 (IR 73 and IR 74); two isolates from CoJ 85 (IR 86 and IR 87) and one isolate each from CoS 91269 (IR 76) and CoS 92423 (IR 77) 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. The virulence pattern of the isolates more or less matched with the existing pathotypes of this zone (Cf 08 and Cf 09). Hence, there was no emergence of any new virulent pathotype in this zone.

Evaluation of zonal varieties against red rot, smut and wilt

North West Zone (ICAR-IISR, Lucknow)

Eighteen genotypes were evaluated against red rot, smut and wilt. Natural incidence of yellow leaf disease (YLD) was also observed. One genotype CoH 11262 was found highly susceptible (HS) to both the pathotypes (Cf 08 and Cf 09) of red rot. One genotype CoS 11232 was found moderately susceptible (MS) to pathotype Cf 08 whereas susceptible (S) to pathotype Cf 09. Five genotype *viz.*, CoLk 11201, CoLK 11202, CoLk, 11206, CoPb 10182 and CoPb 11212 were found moderately resistant (MR) to pathotype Cf 08 and moderately susceptible (MS) to pathotype Cf 09. Remaining eleven genotypes were recorded moderately resistant (MR) reaction to both the test pathotypes (Cf 08 and Cf 09).

Out of eighteen genotypes tested for smut, eleven genotypes *viz.*, Co 10036, CoPant 10221, CoH 11263, CoH 11262, CoLk 11204, CoS 10231, CoPb 11214, CoLk 11203, CoLk 11206, Co 11027 and CoH 10262 were susceptible whereas seven genotypes were tolerant to smut.

Natural incidence of wilt was observed for the above mentioned genotypes. Out of eighteen genotypes tested, five genotypes *viz.*, CoS 10231, Co 11027, CoH 10262, CoPant 10221 and CoPb 10181 were found susceptible to wilt.

Out of eighteen genotypes, seven genotypes *viz.*, CoH 11262, Co 10035, Co 12028, CoPant 12223, CoPant 12224, CoPant 12225 and CoPant 12226 were recorded the natural incidence of Yellow Leaf Disease (YLD).

North Central Zone (ICAR-IISR-RC, Motipur, Bihar)

In North Central Zone, 21 genotypes were evaluated against red rot. One genotype, CoLk 12207 was highly susceptible (HS) to both the pathotypes (Cf 07 and Cf 08) of red rot. Two genotypes, CoP 11436 and CoSe 11451 were recorded susceptible (S) to pathotype Cf 08 whereas moderately susceptible (MS) and

moderately resistant (MR), respectively to pathotype Cf 07. Two genotypes, CoP 11438 and CoLk 09204 were moderately susceptible (MS) to pathotype Cf 08 and moderately resistant (MR) to pathotype Cf 07. Remaining sixteen genotypes were recorded moderately resistant (MR) reaction to both the pathotypes of red rot (Cf 07 and Cf 08).

Natural incidence of wilt was observed for the above mentioned genotypes. Out of twenty one genotypes, two genotypes *viz.*, CoP 11438 and CoSe 10452 were found susceptible to wilt. Remaining nineteen genotypes were recorded free from the wilt disease

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

During 2015-16, total 16 genotypes (Mid late 10 and early 6 early maturing) were evaluated against major insect pests of sugarcane. Planting was done in the month of February 2015.

Ten mid-late maturing sugarcane genotypes (Co 10036, CoPant 10221, CoH 10262, CoPb 10182, CoLk 11204, CoPb 10281, CoH 11263, CoLk 11206, CoPb 11214, CoS 11232) and two standards (CoS 767 and CoPant 9722) were evaluated for their reaction against insect pests of sugarcane. Only one genotype (CoLk 11206) was MS (moderately susceptible) and rests of the genotypes were LS (less susceptible) to top borer (III brood). Against top borer (IV brood), CoH 10262 and CoS 11232 were LS and MS, respectively and others were HS (highly susceptible). All genotypes were found LS to internode borer. Against stalk borer, CoPb 10182 was MS. CoPant 10221, CoH 10262, CoLk 11206 and CoS 11232 were HS and rests of the genotypes were LS.

In early group, only six genotypes (Co 10035, CoS 10261, CoH 10231, CoLk 11201, CoLk 11202, CoLk 11203) and one standard (CoJ 64) were evaluated for their reaction to insect pests of sugarcane. Two genotypes *viz.*, CoLk 11202 and CoLk 11203 showed MS reaction and rest of the genotypes showed LS (Less susceptible) reaction to 3rd brood of top borer. CoH 10231 showed LS reaction to 4th brood of top borer and rest of the genotypes showed HS reaction. CoS 10261 and CoH 10231 were HS and rest of the genotypes were MS to stalk borer. CoH 10231 and CoLk 11201 were LS and rest of the genotypes was MS to internode borer.

Incidence of *Pyrilla perpusilla* was very high but it was managed by its parasite, *Epiricania melanoleuca*.

Parasitisation of top borer larvae by *Rhaconotus* sp., *Stenobracon* spp., *Isotima javensis* was observed. Amongst predatory fauna, coccinellid beetles, spiders and green lace wing were prominent ones.

Survey and surveillance of sugarcane insect pests

In insect pest survey, Command areas of Harinagar Sugar Mill, Harinagar; New Swadeshi Sugar Mills, Narkatiyaganj; Tirupati Sugars Limited, Bagaha; Hasanpur Sugar Mill, Hasanpur; ICAR-IISR (R.C.), Motipur; Bharat Sugar Mills, Sidhaulia and New India Sugar Mills, Dhadha Bujurg, Hata, Kushinagar (U.P.) were surveyed.

In seed plots raised from tissue cultured plantlets of Co 0238 in command areas of New Swadeshi Sugar Mill, Narkatiaganj, West Champaran, Bihar, the incidence of cane borers was high. Incidence of white fly along with cane borers was also observed. At Bharuari farm, Co 0118 was severely damaged by top borer.

In the month of April, 2015, incidence of *Pyrilla perpusilla* was moderate to severe in most of the areas (Fig. 4.3). Adults and egg masses of *Pyrilla* were abundant but number of nymphs were low that may be due to the presence of a good number of Coccinellid (Lady Bird beetles) predators as they feed upon eggs of *Pyrilla* voraciously. Lower surfaces of leaves were almost white due to egg masses accompanied with >100 adults/leaf. A plenty number of predatory fauna constituted mainly of Coccinellids and spiders was observed. Number of *Fulgoraecia melanoleuca (Fletcher 1939) (Epiricania melanoleuca)*- a potential adult and nymph parasitoid of *Pyrilla*) was scanty. At Bargajawa farm of Harinagar Sugar Mills, Harinagar, Shikarpur State (New Swadeshi Sugar Mill, Narkatiyaganj); Bharat Sugar mills, Sidhaulia and at ICAR-IISR-RS, Motipur, scanty number of coccons of *Epiricania melanoleuca* were noticed. In the month of July, 2015 at ICAR-IISR-RC, Motipur and Harinagar Sugar Mill, Harinagar, the incidence of top borer (III brood) ranged from 1.33 to 21.48% in different varieties (BO 154, CoP 112, CoLk 94184, CoLk 9202, CoLk 12207, Co 0233 and Co 0232) while incidence of Plassey borer was 16.25 and 6.42% in SA-04-245 (ISH & IGH lines) and Co 0233, respectively. Larvae of Plassey borer were parasitized by *Cotesia flavipes*, *Stenobracon deesae* to the tune of 9.8 and 3.6 %, respectively. The incidence of *Pyrilla perpusilla* was severe with the range of 13.20-83.80 nymphs and 3.00-10.83 adults/leaf, irrespective of sugarcane varieties but ISH & IGH lines were received low population of the pest. In Harinagar Sugar Mill area, the population of nymphs and *Pyrilla* adults was 42 - 158 and 4.2 - 12.20/cane, respectively in CoP 9301, Co 0118, Co 0238 and CoLk 94184.

a) Plassey borer affected cane and larvae

b) Adults and nymphs of *Pyrilla perpusilla* Walker

c) Nymphs and adults of *P. perpusilla* attacked by *Fulgoraecia melanoleuca* (Fletcher 1939) (Nymph and adult parasitoid)

d) Egg, cocoon and adult stage of *Fulgoraecia melanoleuca* (Fletcher 1939) (Nymph and adult parasitoid of *P. perpusilla*)

Fig. 4.3. Incidence of insects in sugarcane

In command areas of Dr. Vikhe Patil Shakkar Kharkhana, Pravaranagar (MS), incidence of early shoot borer (1-2%), army worm (10-18%) in few fields was observed in leading sugarcane variety CoM 0265.

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

Experiment was conducted with sugarcane variety, CoLk 8102. Periodic observations on incidence of insect pests and parasitoids of pests were recorded.

Incidence of top borer II, III and IV brood was 3.45 to 5.62, 16.71 to 31.42 and 27.03 to 57.35 per cent, respectively. Incidence of root borer at shoot stage was low but in September, it was 40.00 to 55.00 per cent. Incidence of internode borer was 4.76 to 34.28 per cent. Incidence of stalk borer was 2.38 to 16.67 per cent. The incidence of *Pyrilla perpusilla* was severe up to August and it was checked by its parasite, *Fulgoraecia melanoleuca*. Mealy bug was present on almost all the plants. Population of black bug was high ranged from 2-35/plant. White fly appeared in the month of January in traces. Incidence of termites was 9.09 to 29.41 per cent, while after cane formation damage of termites was limited to dry leaves only.

Parasites like *Telenomus beneficiens*, *Stenobracon* sp., *Rhaconotus* sp., *Isotima javensis*, *Fulgoraecia melanoleuca* and predatory fauna comprising of Coccinellids, spiders and ants were noticed in the field at different stages of the crop.

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

Green lace wing, *Chrysoperla carnea* is a predatory insect as its grubs are voracious feeders and feed upon a number of soft bodied insects, eggs and newly emerged borer larvae. Laboratory rearing of this predatory insect was carried out.

It is abundant in monsoon period. Therefore, nucleus culture (adults) of the insect was collected from sugarcane fields in the month of September. Collected male and female insects were allowed for mating in egg laying tray. Egg laying trays were wrapped with black paper on inner surface and covered with black cloth (Fig 4.4). Egg laying trays were supplied with promising protein rich diets combinations and single female laid 400 to 600 stalked eggs on black cloth (Fig 4.5). Eggs are greenish white in colour and appear contrast on black colour of the cloth (Fig 4.6). At black head stage, eggs were separated by cutting their stalks and transferred to glass vials containing freshly laid eggs of *Corcyra*

Rearing of *Chrysoperla carnea*

Fig 4.4. Egg laying tray

Fig 4.5. Artificial diet for adult insects

Fig 4.6. Eggs of *Chrysoperla carnea*

Fig 4.7. Nymph and pupae of *Chrysoperla carnea*

cephalonica (rice moth) and kept at 27°C in BOD incubator for the emergence of larvae (grubs). Newly hatched grubs fed on *C. cephalonica* eggs and larval (grub) stage lasts 14-19 days and adult insects emerged from the pupae in 3-4 days (Fig 4.7). Pupae are polygonal in shape. For the development of grubs, dried goat liver powder and yolk of hen egg based diets were accepted by the grubs and they completed their stage successfully and converted to pupae. For mass rearing of the insect plastic cages, glass jars and tissue culture plates with multi wells were also used. Egg, grub, pupal and adult period is 3-4, 14-19, 6-7 and 15-20 days, respectively when multiplied on artificial diets.

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. Planting was done in the month of February, 2015. In half of the area, six sex pheromone traps at the distance of 20 meter apart were placed when the top borer moth was seen in the field. Moth catches were recorded daily. Trapped moths were removed from the trap after recording their number. No sex pheromones for other borers was available.

Six sex pheromone traps were installed in 0.5 acre sugarcane field and half of the acre field was kept without traps for comparison. Sex pheromone lures for top borer were procured from PCI, Bangalore (India). Moth catches were recorded daily. Water and mobil oil were changed daily when moth catches were recorded. Trapped moths were removed from the trap after recording their number. In second and third brood, catches were observed, while in fourth brood, low catches were observed.

Total number of male moths of top borer (II brood) caught in traps was 337 (56.17 moths/trap), total catch of top borer moth (III brood) was 166 (27.67 moths /trap) and of IV brood was only 77 (12.83/trap).

Incidence of top borer (II brood) in plot with traps ranged from 3.45-5.62% (average 4.77%) as against 4.39-8.89% (average 6.74%) in without traps. Incidence of top borer (III brood) in plots with traps and without traps were 5.20-16.30% (average 11.69%) and 7.78-23.33% (average 14.80%), respectively. Incidence of IV brood was severe 28.62-48.57%

(average 38.13%) incidence in plot without trap was 25.00-45.00% (average 32.89%). No significant difference in top borer incidence was recorded in plots with and without sex pheromone traps.

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

Nine varieties of sugarcane *viz.*, CoJ 64, CoLk 94184, CoS 8436, Co1148, CoLk 8102, CoSe 92423, SES 594, Baragua and Khakai have been explored regarding associated rhizospheric microbial diversity. Sum total of 16 mycoflora genera and 120 numbers of bacterial colonies have been isolated by deploying Potato Dextrose Agar, Rose Bengal Agar and Nutrient Agar media using serial dilution factor 10^{-3} to 10^{-6}. According to plant age of different varieties, overall the association of mycoflora (fungi) in rhizospheric region keeps on building with the age of crops up to 250 days. Grand growth phase of the crop resulted in the highest number of rhizospheric microbial association with all the experimental varieties including three different checks. The rhizospheric zone of fifty days age crop was found associated with 13 fungal genera namely *Fusarium, Alternaria, Rhizoctonia, Trichoderma, Penicillium, Cladosporium, Acremonium, Chaetomium, Rhinocladiella, Candida, Aspergillus, Rhizopus* and *Mucor*. At the stage of advance tillering phase (100 days of crop age), fifteen mycoflora genera were found associated in rhizospheric region. Out of these fifteen genera, 13 were found associated with root zone at the stage of fifty days crops whereas *Verticillium* and *Nigrospora* were the two new associations increased during the tillering phase. One more association namely *Candida* got increased during the grand growth phase of the crop (150 days), resulting 16 in numbers of mycoflora genera. The mycoflora genera, *Candida* got disappear before the start of ripening and maturation phase of the crop from rhizospheric microbial association (250 days crop age) where simple sugars (monosaccharide *viz.*, fructose and glucose) are converted into cane sugar (sucrose, a disaccharide). *Curvularia, Pythium, Verticillium, Nigrospora, Paecilomyces, Epicoccum, Acremonium,* and *Cladosporium* were the genera found different from the germination and establishment phase (at 50 days) to starting of tillering phase. These genera of mycoflora got build up in rhizospheric microbial association during the grand growth phase and keep on continuing up to ripening and maturation phase of the crop, especially with the high sugar early maturing varieties as compared to low sugar varieties.

5

Basic research in physiology and biochemistry

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 ppm ethrel) was performed at the start of ripening phase (in the month of October) using variety BO 91 (a mid late maturing variety) for improving sucrose content in cane stalk. Sucrose content in cane juice was determined in the months of December, January, February, March and April. Improvement in sucrose per cent in juice was relatively high in the months of December (1.77%), January (1.98%) and April (2.06%) as compared to February and March (<1.0%) (Fig. 5.1).

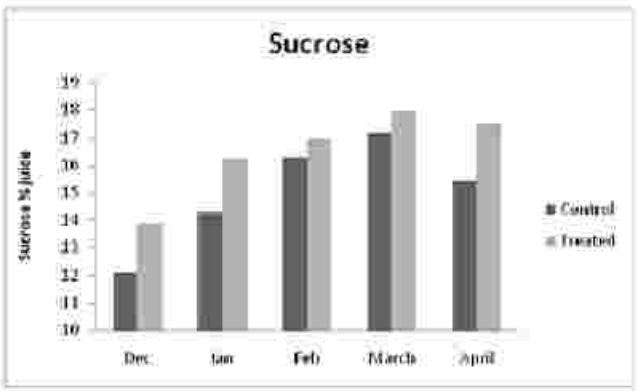


Fig. 5.1. Improvement in sucrose per cent juice in the months of December, January and April as compared to February and March

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

Reverse transcriptase-PCR analysis: Gene specific primers namely soluble acid invertase (SAI) and sucrose synthase (SuSy) was used to carry out the qRT-PCR. The differential expression of SAI gene was observed as expression was higher in immature than

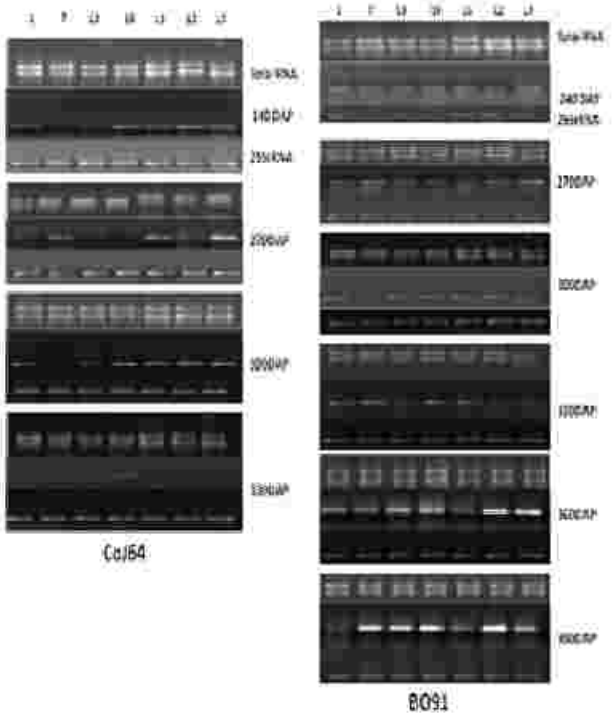


Fig. 5.2 Expression patterns of SAI and SPS genes in early (CoJ 64) and late (BO 91) maturing varieties in 1st, 7th, 13th and 16th internodes and sink, LTM and source leaves at different days after planting (DAP)

internodes, as CoJ 64 is early maturing and it had started maturing from basal region of the cane. SAI expression decreased with the maturity. In leave tissues, SAI expression was always observed high in LTM, a highly active leaf. As sucrose synthase primarily breakdown the sucrose, its expression at 240 DAP in both the varieties was almost nil. SuSy expression were found in BO 91 at 360 and 390 DAP as sucrose content was at its peak.

Transcriptome analysis: For transcriptome analysis,

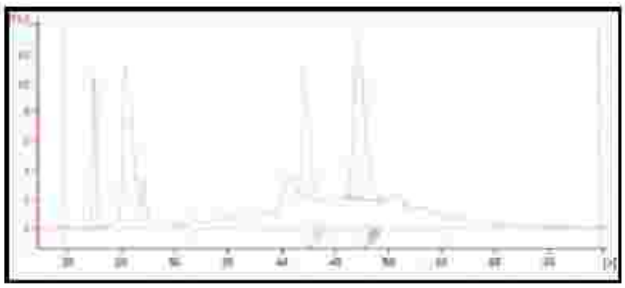


Fig. 5.3. Quality of total RNA isolated for transcriptomic study

Transcripts were sequenced using illumina HiSeq 2X100bp 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. Each of the samples produced 11 to 18 million read counts of each of 100bps length having almost 50% GC content. *De novo* assembly statistics indicated a total of 2.0 lakh transcripts having about 1.3 lakh genes. Average length of contig was 707bps. Expression analysis indicated >1 lakh differentially expressing transcripts among two sets of samples. Of these, around 3,000 transcripts were significant differentially expressing. Heat map also showed the level of the differential expression of transcripts and phylogeny among transcripts based on DNA sequences.

Minimizing post-harvest sucrose deterioration and its molecular assessment

In order to verify the extent of loss caused by microbes, canes from 34 fields were used to isolate *Leuconostoc* species from juice. Serial dilutions were made for each sample and 100 µl of diluted sample were spread in duplicate, into plates containing MRS agar medium supplemented with 30 µg/ml vancomycin and 0.005% sodium azide, and incubated overnight at 30°C.

Morphological and genetical identification of *Leuconostoc spp.*: Strains from each sample were purified by sub-culturing on MRS and MSE agar plates, followed by microscopic examination (Fig. 5.4). The purified isolates were initially tested for Gram stain, cell morphology, H_2O_2 production and spore formation. Strains with positive Gram, diplococcic shape, catalase negative and non-spore formation were selected for further identification. These strains were tested for physiological characters and CO_2 production from glucose, growth at different temperatures (4, 15, 30, 37 and 45°C) for 5 days and at different pH (4.8 to 6.8), resistance to different NaCl concentrations (3 to 6.5%). Carbohydrate fermentation was performed on MRS supplemented with bromocresol purple as a pH indicator, by using sugars (arabinose, maltose, rhaminose, esculine, mannitol, sorbitol, galactose, lactose, fructose, glucose, sucrose, and xylose) to differentiate between sub-species of *Leuconostoc*. Of all the strains considered in this study, twenty four were phenotypically identified belonging to the *Leuconostoc* genus based on the following criteria's: ovoid shape, Gram positive, catalase negative, vancomycin-resistant, production of gas from glucose, no arginine hydrolysis, and by their fermentation profiles. Twenty *Leuconostoc* samples were isolated from 34 sugarcane juice samples. All the colonies exhibited a glutinous transparent aspect on MRS agar. All 20 isolates were Gram positive, ovoid shaped, associated in pairs and/or short chains, with negative catalase reaction, able to produce carbon dioxide from glucose but unable to hydrolyze arginine. All the isolated strains exhibited growth at 15, 30 and 37°C but not at 4 and 45°C. Contrary to pH 4.8, pH 6.5 was found more suitable for the growth. Carbohydrate fermentation profile showed that all the isolates used glucose, galactose, lactose, maltose, fructose as carbon source but not the arabinose, raffinose, rhamnose, sorbitol, manitol, ribose, saliciline and starch.

To design species specific primers, 16S rDNA sequences of a total of eight *Leuconostoc* species were used. A total of 12 species specific primers, both forward and reverse for six *Leuconostoc* species were designed. The primers were selected from the most varied regions of 16rDNA sequences of the *Leuconostoc* species.

1 2 3 4

Species specific primers for *Leuconostoc* were tested using all extracted DNA. The species specific primer for *Leuconostoc lactis* produced a PCR product of the expected molecular weight (742bp) with all twenty three isolates (Fig. 5.5). The other seven species specific primers set (*L. argentinum, L. carnosum, L. citreum, L. fallax, L. gelidum , L. mesenteroides* and *L. pseudomesen teroides*) did not produce any PCR product with all twenty isolates. DNA sequencing of the 13 selected isolates revealed high homology among their 16S rDNA nucleotide sequences. In addition, sequence analysis by the BLAST tool against other sequences from reference strains deposited in the GenBank revealed a 98% homology with *L. lactis*.

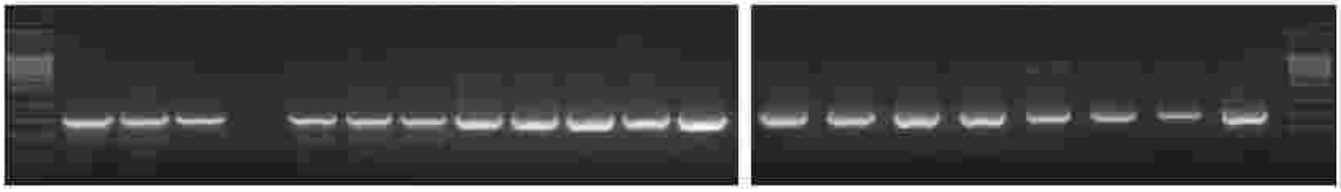


Fig. 5.5. Amplification products obtained from *Leuconostoc lactis16s rDNA* species specific primer showing a product of 742bp

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

Eighteen sugarcane germplasm/lines; CoLk 12204, CoLk 12202, CoLk 12206, CoLk 07201, CoLk 04238, LG 06605, LG 04439, LG 05350, LG 05020, LG 03040, A-46-11, B-44-12, A-27-12, D-12-9, D-6-13, S 5085/11, S 5087/11, S5090/11 and six commercial varieties; CoLk 94184, BO 91 , CoS 767, CoJ 64, CoS 97264, UP 9530 of sugarcane were evaluated for waterlogging tolerance at Kharika Block, ICAR-Indian Institute of Sugarcane Research, Lucknow. For waterlogging treatment, crop was grown in deep plot which was waterlogged during grand growth phase. Results obtained indicated:

- Aerial rooting, crop lodging and leaf chlorosis due to waterlogging
- Reduced chlorophyll and carotenoids contents in waterlogged affected leaves of most of the sugarcane genotypes except in CoS 767, CoLk 12206, D-12-9, D-6-13 and S5085/11.
- Leaves of waterlogged affected plants showed relatively lower phosphorus content in most of the genotypes except in CoS 767, CoLk 12206, CoLk 07201, CoLk 04238, LG 06605, S 5085/11 and S5090/11.
- Based on relative cane weight, CoLk 12206, LG 06605, LG 04439, D-6-13 and S5085/11 were identified as the most waterlogging tolerant lines.

6

Mechanization of sugarcane farming

Development of modified furrower type sugarcane cutter planter

Prototype of tractor operated PTO-driven deep furrow sugarcane cutter planter was developed and field tested at ICAR-IISR farm. Three more prototypes were fabricated in the workshop and supplied to Muzaffarnagar and Bahraich (both in U.P.) (Fig. 6.1a) and ICAR-IISR Regional Centre, Motipur, Muzaffarpur (Bihar) for conducting field trials at farmers field (Fig. 6.1b). It performs all the unit operations involved in sugarcane planting *viz.*, sett cutting, deep furrow opening, placement of setts into furrows, application of fertilizer and insecticide solutions in the furrows and soil covering over setts and pressing the soil cover with a tamping roller, simultaneously in a single pass of the equipment. Effective field capacity of the planter was 0.20 ha/h. There is a saving of approximately 50% in the cost of planting operations by using this planter as compared to conventional planting.

Herbicide spraying attachment was developed and integrated with deep furrow sugarcane cutter planter (Fig. 6.2). The new prototype performs all the unit operations involved in sugarcane planting (furrow opening, sett cutting, sett placement in furrows, fertilizer and insecticide application, soil covering over setts and its tamping simultaneously) and spraying of pre-emergence herbicide simultaneously in a single pass. It saves the cost of pre-emergence herbicide application which otherwise is performed separately after sugarcane planting.

Fig. 6.2 Developed deep furrow sugarcane cutter planter with herbicide spraying attachment

Design refinement of tractor operated sugarcane-cum-potato planter

The sugarcane-cum-potato planter was field tested at experimental farm of the Institute. Two varieties of potato *viz.*, Kufri Khyati (spherical type variety) and Kufri Fry Sona (elliptical type variety) were planted as intercrop with sugarcane in the last week of October 2015 by the planter as well as manually. Field testing results revealed that the designed potato seed metering unit placed seed potato at predetermined spacing over the ridges formed in

Table 6.1 Test results of sugarcane-cum-potato planter

Means of potato planting	Potato plant population ('000/ha) after one month of planting		Potato yield (t/ha)		Sugarcane plant population ('000/ha)	
	Kufri Khyati	Kufri Fry Sona	Kufri Khyati	Kufri Fry Sona	After 45 days of planting	At the time of potato harvesting
Planter	77.52	52.17	24.00	19.20	50.26	66.41
Manual	78.67	53.33	24.89	20.13	49.13	64.17
SE±	2.95	2.87	1.76	2.22	2.87	7.05
CD	NS	NS	NS	NS	NS	NS

Fig. 6.3 Developed sugarcane-cum-potato planter in field operation

Development of tractor operated sugarcane manager

Prototype of tractor operated sugarcane manager was field tested for interculturing of sugarcane. The row spacing was 75 cm. It covers three inter-row spaces of crop. Intra-row spacing was intercultured manually by using spade. Dry weight of weeds prior to interculturing and after interculturing with the manager was recorded and weeding efficiency was worked out. Weeding efficiency was 80 per cent by using the developed sugarcane manager. The effective field capacity of the sugarcane manager during interculturing was 0.35-0.40 ha/h. Prototype was tested for sowing of intercrops in the inter-row spacing of sugarcane. Seed metering mechanism consisted of PVC casing and metering rollers. Metering rollers were edge cell PVC rotors. The seed rate was regulated by adjusting the gap between the casing and rollers. The effective field capacity of the

tool frame (Fig. 6.4) was designed and developed particularly for sugarcane which can be used for performing different operations with different attachments and for year round use. The overall dimension of tool frame is 2250 x 600 x 1250 mm. M.S square pipe of size 60 x 60 x 5 mm was used for fabrication of tool frame. The tool frame has been designed keeping in view the sugarcane furrow spacing of 75 and 90 cm. The tool frame has provision of attaching different attachments for furrow opening, deep tilling, fertilizer application, interculturing, weedicide application and earthing up. The prototype was developed as a possible solution to farmers reluctance for purchasing a single operation specific and cost of equipment having economic considerations.

Fig. 6.4 Multipurpose tool frame under fabrication

Development of tractor operated sugarcane harvester for small farms

Tractor operated rear mounted sugarcane

AICRP on FIM

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

Prototypes fabricated

Name of the equipment	Quantity (No.)
Tractor operated deep furrow sugarcane cutter planter	4
Tractor operated deep furrow sugarcane planter-cum-raised bed seeder	1
Tractor operated trench/paired row cane planter	1
Tractor operated furrower	4
Tractor operated trencher	1
Modification of sugarcane-cum-potato planter	1
Tractor operated disc type ratoon management device	1
Tractor operated deep furrower-cum-fertilizer applicator	1
Manual sett cutting machine	5
Manual cane bud scooper	6
Manual cane detrasher	2
Total	**27**

Prototypes supplied

Name of the equipment	Quantity (No.)	Supplied to
T.O. disc type ratoon management device	1	MPKV, Rahuri, MS
T.O. deep furrow sugarcane cutter planter	1	ICAR-IISR Regional Centre, Motipur Bihar
T.O. deep furrow sugarcane cutter planter	1	Bahraich, UP
T.O. ground wheel driven two row sugarcane planter	1	Sultanpur, UP
T.O. raised bed seeder-cum-fertilizer applicator	1	ICAR-IIPSR, Modipuram, UP
T.O. sugarcane trencher	1	
Manual cane detrasher	1	Mr. K.N. Singh, Kichchha, Udham Singh Nagar, Uttarakhand
Manual cane stripper	1	
Manual sett cutting machine	1	Mr. Vinay Shukla, Industrial Area, Sandila, Hardoi, UP
Total	**09**	

Note : These prototypes were manufactured and supplied by ICAR-IISR, Lucknow

7

Diversification and value-addition in sugarcane

Development of a jaggery furnace with efficiency boosting device

A miniature model of efficiency boosting device (203 mm x 203 mm) was developed. The unit had holes on its body for directing flames and hot gases to pan bottom. Holes gave venture effect that was not desired. Therefore, the unit has been modified and nipples of 10 mm length and 4 mm diameter were provided to all the 21 holes made for exit of air. The unit is ready for testing.

Optimizing packaging method for enhancing shelf life of granular jaggery

In a study, granular jaggery procured from Meerut *mandi* was stored under different packaging conditions, *viz.*, normal, vacuum, nitrogen and carbon dioxide filled conditions in five different packaging materials *viz.*, polypropylene, low density polyethylene, high density polyethylene, polyethylene terephthalate and metallic laminated plastic film (Fig. 7.1). Samples from each method were drawn at an interval of one month for evaluation of physical, biochemical and microbial changes. Changes in moisture content, angle of repose, bulk density, true density, optical characteristics, sugar content, reducing sugar, phenolic content, pH, electrical conductivity, total bacteria and fungi were determined.

Fig. 7.1. Various packaging methods used for enhancing shelf life of granular jaggery

scrapping. The unit is also provided with washing arrangement by recirculation of water. Wire brushes have been provided on all the three scrubbing rollers for better scrubbing (Fig. 7.2). The unit was tested but problem was observed with scrubbing rollers. These rollers failed to clean canes near the nodes. Therefore, wire mesh has been replaced with wire brushes on scrubbing rollers. The unit is ready for testing.

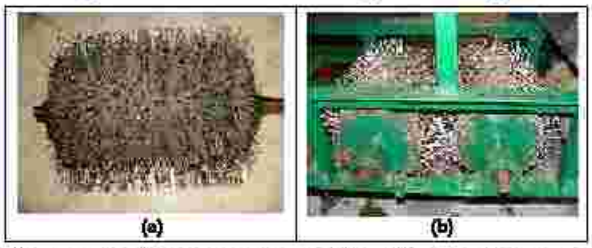
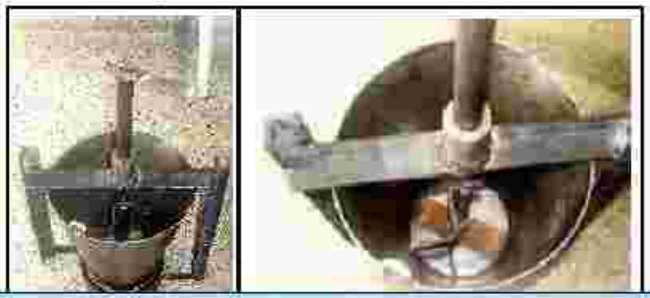


Fig. 7.2. Modified scrubbing rollers (a) Wire brush on roller and (b) Scrubbing rollers

Development/adoption of suitable mixer for production of value-added jaggery using *aonla* as a natural source of vitamin C

A manual mixer for mixing of *aonla* shreds in jaggery slurry for production of value-added jaggery was designed and developed. It has been designed for a capacity of 13 kg of value-added jaggery to be mixed in a stainless steel container (Fig. 7.3). Modifications in mixing arrangement have been incorporated. The mixer is ready for use.



the quantity of some of the common Indian spices have been optimized for value addition in jaggery. These were mixed thoroughly with the help of manual mixer in the cooling tray and then moulded in pieces of 25 mm x 25 mm x 12.5 mm (10 g) using ICAR-IISR jaggery moulding frame. After removal from frame, these were packed individually using butter paper and aluminium foil. Based on organoleptic evaluation, dried ginger powder (25 g), turmeric powder (15 g), caraway seeds (10 g), black pepper powder (15 g), asafoetida (1.5 g), nigella seeds (15 g) and sesame seeds (400 g) per kilogram of jaggery was finalized for addition in jaggery (Fig. 7.4).

Fig. 7.4. Value-added jaggery with Indian spices

Development of a semi-automatic jaggery manufacturing plant

A wet and dry vacuum cleaner was procured and used for scum removal from the pan during juice clarification. Two types of hoods were also tried. As the purchase of gear pump is under process, efforts were made to pump the concentrated jaggery from boiling pan to cooling unit using the principle of vacuum suction. A tank was properly sealed and vacuum was created in the tank with the help of available vacuum pump. Through a pipe and valve arrangement, the concentrated jaggery was sucked into the tank. The principle was successful and based on this, a machine is being designed and developed.

Protein enrichment of jaggery

An exploratory trial for protein enrichment of jaggery with natural source (soybean) was taken. Water soaked soybean was made into paste and added to sugarcane juice and jaggery was prepared. Analysis of samples showed increase of protein content from reported value of 0.4% in plain jaggery to 5%. Further research for the development of protocol is under active consideration.

Optimization of parameters for shelf life enhancement of jaggery under modified atmosphere packaging

During the period of study, the moisture content initially decreased but increased during rainy season (July-August). The hardness has an inverse trend, it first increased and then decreased during rainy season.The phenolic content and reducing sugar showed a increasing trend throughout the storage period but the rate of increase was more during rainy season. A shelf life prediction model was developed using multiple regression technique.

Multiple regression analysis was carried out to find a regression model to predict shelf life of jaggery in terms of BI, RS and TP. Since the P-value was less than 0.01, there was a statistically significant relationship between the variables at the 99% confidence level.

$t = -246.317 + 18.2205 \times BI - 11.4579 \times RS + 0.196218 \times TP$

Where,

BI= Browning index

RS= Reducing sugars in per cent

TP= Total phenols in mg/100 g

t= Duration in days

8

Sugarbeet Research

Developing sugarbeet varieties suitable for Indian agro-climates

The primary objective of a long-term project is to develop and identify sugarbeet varieties suitable for cultivation under Indian agro-climates. The work is carried out at two locations; –at ICAR-IISR, Lucknow (root crop trials) for evaluating the potential varieties for commercial cultivation of sugarbeet and at Mukteswar Outpost in Uttarakhand for breeding and seed production. During the year under report, a root crop trial was sown in November 2015 at Lucknow with sixteen entries comprising of indigenous and exotic varieties, along with suitable controls (Table 8.1).

Table 8.1 Sugarbeet varieties planted for root crop trial at Lucknow

Category	Variety
Indigenous	IISR-Comp-1, LKC-2000, LKC-2006, LKC-2007, LKC-10, LKC-HB, LKC-LB, LK-4, LK-7, R-06*, L-33**
Exotic diploid hybrids	PAC-60008, SZ-35, SV-894
Control/Check	LS-6, Shubhra

Note : *An introduced USSR diploid variety while,
**An introduced line.

The germination, growth and crop stand were very good. An impressive leaf canopy development promised a good root yield. The root crop trial was harvested in April and May, 2016. Six sugarbeet hybrids of the Belgian sugarbeet seed company, SBS Vanderhave were evaluated at different dates of sowing. The 2015-16 experiment was conducted with three dates of sowing *viz.*, October 31 (D_1), November 14 (D_2) and December 1, 2015 (D_3).

The middle of November (D_2) was found optimal for sowing sugarbeet in terms of sugar content and sugar content, this was the leading hybrid. Though not among the highest root yielders, SV-893 made up in gross sugar through higher sugar content in the roots and the lowest impurity index due to Na. K and α-amino Nitrogen content in the juice (Fig. 8.2). The other hybrid that did well was SV-894. These two were found at par in sugar yield with the high sugar check variety, Shubhra (A Syngenta variety). Root rot incidence was the highest in SV 887 (14.7%), while it was the lowest in the Indian variety, LKC-2010 (7.4%). SV-893 and the indigenous varieties had relatively lower incidence (Fig. 8.3).

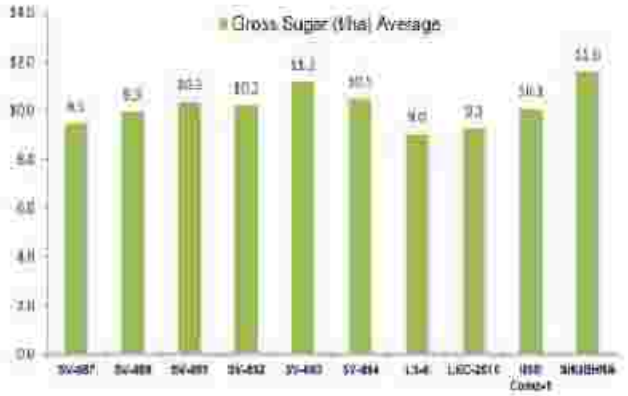


Fig. 8.1. Mean sugar yield of sugarbeet varieties

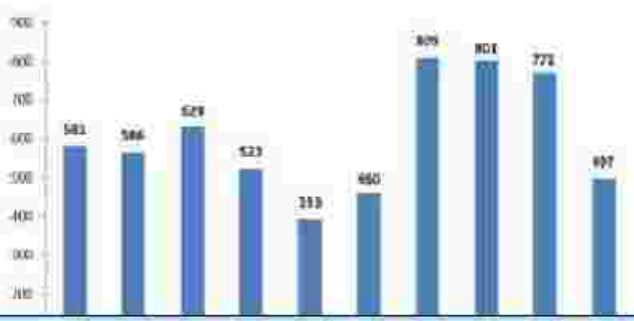


Table 8.2. Performance of sugarbeet varieties w.r.t. different dates of sowing

Treatment	Plant pop^n/ha	Root yield (t/ha)	Root weight (kg) April end	Root weight (kg) May end	Sucrose content (%) April end	Sucrose content (%) May end	Gross sugar (t/ha) April end	Gross sugar (t/ha) May end
Date of sowing (D)								
D1 (31.10.2015)	78029	79.4	1.050	1.082	13.97	12.18	11.102	9.645
D2 (14.11.2015)	77685	78.8	0.942	0.796	14.68	12.62	11.580	9.927
D3 (01.12.2015)	78426	69.4	0.727	0.633	14.45	12.47	10.024	8.636
CD 5%	NS	5.9	0.120	0.099	0.49	NS	0.960	0.901
CV%	8.6	10.8	18.4	16.4	4.8	14.6	12.3	13.4
Variety (V)								
SV-887	78792	75.3	1.116	0.904	12.76	12.40	9.592	9.328
SV-889	79806	77.1	0.896	0.804	14.14	11.67	10.906	8.968
SV-891	79541	76.8	0.909	0.838	14.27	12.77	10.927	9.740
SV-892	77910	77.9	0.975	0.906	13.68	12.51	10.677	9.748
SV-893	76896	72.7	0.866	0.772	16.66	14.11	12.122	10.207
SV-894	76852	76.8	0.999	0.949	15.03	12.26	11.543	9.404
LS-6	73369	71.8	0.871	0.819	13.26	11.86	9.548	8.490
LKC-2010	77513	74.1	0.815	0.780	13.55	11.45	10.027	8.493
IISR Comp-1	80291	77.9	0.819	0.759	13.97	11.86	10.892	9.247
Shubhra	79497	78.0	0.800	0.839	16.35	13.34	12.786	10.401
Mean	78047	75.8	0.907	0.837	14.37	12.42	10.902	9.403
CD 5%	NS	NS	0.147	0.136	0.83	0.70	0.965	0.941
CV%	5.6	7.1	17.2	17.2	6.1	6.0	9.4	9.2
D × V interaction	NS	NS	**	**	**	**	*	NS

Table 8.3 Effect of dates of sowing on root yield of sugarbeet varieties

(Root yield index value)

Variety	D_1 (31.10.2015)	D_2 (14.11.2015)	D_3 (01.12.2015)
SV-887	100	104	93
SV-889	100	91	76
SV-891	100	101	83
SV-892	100	94	85
SV-893	100	99	85
SV-894	100	98	89
LS-6	100	98	88
LKC-2010	100	104	95
IISR Comp-1	100	101	89
Shubhra	100	104	93
Overall	**100**	**99**	**88**

At the Sugarbeet Breeding Outpost in the premises of ICAR-IVRI at Mukteswar in Kumaon hills of Uttarakhand the maintenance of germplasm and limited seed production of indigenous varieties was carried out. In all, 53 germplasm lines comprising of inbreds, varieties, composites and elite selections were raised. Nearly 40 kg of sugarbeet seed was harvested in July-August 2015, the bulk being constituted by that of the indigenous varieties and the open-pollinated ICAR-IISR variety, LS-6. The seed, primarily of LS-6, was supplied to KVKs, ICAR-CSSRI Regional Station at Lucknow, National Sugar Institute at Kanpur and for experimentation and also for field demonstrations at ICAR-IISR, Lucknow farm.

Evaluation of new herbicides for major sugar crops with special reference to sugarbeet in relation to weed dynamics

Research, Lucknow during 2015-16 revealed that the sugarbeet crop faced intense competition with different types of weed flora like *Cyperus rotundus* (16.2%), broad leaf weed (60.6%) and grasses (18.0 %) at early stage of crop growth (up to 60 DAP). The major broad leaved weeds found in the sugarbeet field was *Carnepus didicas, Anagallis arvensis, Canvolvulus arvensis, Postulaca oleracea, Vicia sativa, Chenopodium album, Mililotus indica, Lawnia asptenifelia* and *Argemone maxicana.* The germination of sugarbeet was recorded about 75 per cent after 15 days of sowing. The obsevations on weed flora and effect of herbicides are under progress.

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

A survey of 12 sugarbeet farmers was undertaken in Amritsar district of Punjab where the sugarbeet cultivation is being carried out by the farmers' on large scale. The survey was undertaken to carry out the economics of sugarbeet cultivation as well as to understand the changes over time in its cultivation. Sugarbeet cultivation was introduced in the area in more than 20,000 ha area during the sugar season 2012-13 with the extension efforts of the sugar mill. However, during 2015-16, after three years of the start, the sugarbeet cultivation in the mill area has been reduced by about 75% of the 2012-13 level and has been planted only by 5% of the beginner beet growers in the area. The economics of sugarbeet cultivation was worked out based on the information gathered from growers and it was found that the per ha total production cost of sugarbeet is varying from ₹ 66,000 to ₹ 73,000. In addition to this, the transportation cost of the sugarbeet from fields to the sugar mill is ₹ 7,500 per ha. The farmers are reaping a harvest of 87.5 tonnes per ha of sugarbeet and earning gross returns at ₹ 1,48,750 on an average. The net returns are ranging from ₹ 68,000 to 75,000 on account of cultivation of this short duration crop. The cost of cultivation was estimated for each component and it is evident that human labour is the major cost component accounting for 39% of the total production and marketing cost. In contrast to sugarcane, the extent of cost on account of machine labour use is also high (21 to 26%) in sugarbeet. The third major component of cost is manures and fertilizers. The practices of sowing seed, harvesting and uprooting of the crop is also mechanized and the mechanization is being reflected in reducing the cost of cultivation per ha as given in Scenario 2 of the Table 8.4. The information on the package of practices followed by the growers for successful sugarbeet cultivation was obtained and its analysis revealed that there is no production side constraint which is hampering the cultivation of sugarbeet crop in the area. The constraints are from the marketing side. The marketing system being followed for sugarbeet is the same as that for sugarcane. Even though the price offered for sugarbeet is less than the price of sugarcane, it was reduced after one year on the

Table 8.4. Economics of sugarbeet cultivation on commercial scale (₹/ha)

Input	Scenario 1	Scenario 2	% of TVC* of Scenario 1	% of TVC* of Scenario 2
A. Cost Components				
Human labour (including contract harvest labour)	31500	22500	38.96	30.62
Machine labour	17400	19400	21.52	26.40
Seeds	2500	2500	3.09	3.40
Manures and fertilizers	9850	9850	12.18	13.40
Irrigation water use	3600	3600	4.45	4.90
Pesticides including herbicides	5000	5000	6.18	6.80
Others	3493	3143	4.32	4.28
Total production cost	73343	65993	90.72	89.79
Transport/Marketing cost	7500	7500	9.28	10.21

contrary. The price of the sugarbeet being offered by the sugar mill during 2015-16 was ₹ 170 per tonne, and was less by ₹ 10 a tonne from the previous year price. The low sugar price existing in the market is reported to be the reason for such development.

Since the sugarbeet cultivation on large scale is of recent origin, its cultivation needs to be nurtured carefully and with utmost sensitivity. Its marketing system needs to be made different than that exists for the cane. If proper price is not paid to the farmers, the chances are there that prospects of recently introduced sugarbeet cultivation may fade away. Possibilities of subsidizing the crop cultivation and marketing cost, and providing incentives of price need to be further explored.

9

Economics and ICT

Extent of pulse cropping in sugarcane intensive tracts of UP

An exploratory study was undertaken to estimate the extent of intercropping in sugarcane in Uttar Pradesh to mark the beginning of the International Year of Pulses. In Uttar Pradesh, sugarcane cultivation is carried out quite intensively and, in some of its districts, more than 50% of net sown area (NSA) is allocated for sugarcane cultivation. Based on a study of cane intensive districts of Uttar Pradesh, it was found that the extent of pulse area is quite low (1.39%, 2.31% and 4.22% of GCA) in very high, high and medium intensive sugarcane areas, respectively (Table 9.1). The sugarcane cultivation in these areas was to the extent of 61-63%, 36-38% and 16-23% of NSA, respectively during the period from 1999-00 to 2014-15. The extent of pulse area in these areas has remained low during the last 15 years (1999-00 to 2013-14). The extent of pulse area is inversely correlated with the extent of sugarcane area, the correlation coefficient being -0.54. In these areas, *Zaid* pulses (Urdbean and Mungbean) have suffered a lot during the period from 1999-2000 to 2013-14, and their extent have changed from 0.59% to 0.14%. *Rabi* pulses (Chickpea, Fieldpea, Pigeonpea and Lentil) and *Kharif* pulses (Urdbean, Mungbean and Mothbean) have marginally improved their share in very high and high sugarcane intensive category, but the increase is quite insignificant. The total pulse area is just 0.032 ha, 0.098 ha and 0.29 ha per ha of sugarcane area in districts of Uttar Pradesh having more than 50%, 30-50% and 15-30% NSA under sugarcane, respectively.

The perceptions of 25 cane growers surveyed in these areas highlighted that the menace of the blue bulls is the major factor responsible for discouraging farmers to grow pulses in these areas *inter alia*. Intercropping of pulses in sugarcane has got impetus where the blue bull menace was effectively managed. If 25% of sugarcane area adopts intercropping, it will provide around 5.0 lakh ha of additional area for the cultivation of at least one pulse crop without reducing acreage under any other crop. The intercropping of pulses in sugarcane was found to be encouraging the adoption of wider row spacing for sugarcane, and in turn, facilitating the mechanization of sugarcane crop. In this way, it will help in addressing the national concern of increasing the area under pulses too.

Table 9.1. Pulse area intensity in sugarcane intensive zones in Uttar Pradesh

Pulse group	Extent of area under pulses in sugarcane intensive zones (ha)							
	Very high		High		Medium		All UP	
	1999 -00	2014 -15	1999 -00	2014 -15	1999 -00	2014 -15	1999 -00	2014 -15
	Pulse area per ha of sugarcane area							
Rabi	0.015	0.022	0.086	0.064	0.445	0.246	1.142	0.782
Kharif	0.005	0.008	0.011	0.029	0.050	0.038	0.148	0.240
Zaid	0.009	0.002	0.011	0.005	0.018	0.007	0.075	0.040
Total	0.031	0.032	0.110	0.098	0.520	0.291	1.322	1.062
	Pulse area as per cent of NSA							
Rabi	0.94	1.434	3.37	2.352	7.48	5.672	2.569	10.502

Impact of IISR technologies in sustaining sugarcane production in India

Potential ICAR-IISR technologies were reviewed and six technologies were identified for working out the socio-economic analysis. During the period under reference, ICAR-IISR developed Sugarcane- Cutter-Planter was selected for analysis. As the machine is being popularized by the Institute for the last so many years, there is no authentic information on the number of sugarcane cutter planters. Even the MOUs were signed with the private manufacturers so that its demand could be assessed. However, the manufacturers could not provide any details on the number of machines sold by them. Efforts were made to compile the information on this machine. It has been found that the machine has very good acceptability and its use is resulting in reducing the labour requirement per hectare and in reducing the cost of cultivation. 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 lacs cane growers who are using sugarcane cutter planters (Table 9.2). These sugarcane cutter planters are also very popular with the small cane growing holdings as these growers using these machines constitute 62.75% of the total users of the machine. A look into the state-wise users of the machine reveals that Uttar Pradesh is having the largest number of users (76,734) followed by Tamil Nadu (53,851), Andhra Pradesh (45,310) and Haryana (19,278) (Table 9.3).

Table 9.2. Cane holding-size wise number of cane growers using Sugarcane Cutter Planter in India

Size Group (ha)	Sugarcane Cutter Planter (Tractor Drawn)	Per cent to All Group Total
Marginal (Below 1.0)	164911	62.75
Small (1.0 - 1.99)	51037	19.42
Semi-medium (2.0 - 3.99)	30111	11.46
Medium (4.0 - 9.99)	14235	5.42
Large (10 and above)	2528	0.96
All groups	262822	100.00

Table 9.3. State-wise number of cane growers using Sugarcane Cutter Planter in India

State	Sugarcane cutter planter (tractor drawn)	State	Sugarcane cutter planter (tractor drawn)
Uttar Pradesh	76734	Madhya Pradesh	5851
Bihar	11644	Assam	599
Haryana	19278	Chattisgarh	1192
Gujarat	6698	Jharkhand	360
Maharashtra	12187	Himachal Pradesh	442
Karnataka	12001	Jammu & Kashmir	1685

Factors contributing economic viability of sugar mills and energy production complexes in India

This project was initiated to study the economics of sugarcane cultivation and it's processing for sugar-energy production in India. To fulfill the objectives of the project, during sugar season 2015-16, the primary data was collected from 10 sugar mills from district Bijnore, Bareilly, Shahjahanpur, Sitapur and Kushinagar. The selected sugar mills were classified as standalone or integrated complexes, cooperative sector mills or private sector mills. Besides the sugar mills, primary data were also collected through personal interview with the help of survey schedule from 17 cane cooperatives societies and 170 sugarcane farmers to study level of sugarcane production technology adoption and to estimate the comparative economics of sugarcane with competing crops. The simple tabular analysis and statistical methods were used to work out cost-return and relative profitability of sugarcane with other crops. The impact of various improved cane production technologies was assessed at respondent and sugar mills level.

Economics of sugarcane production in Uttar Pradesh

The cost of sugarcane production in Uttar Pradesh was worked out on the basis of data collected during sugar season 2015-16. The cost of production for plant and ratoon was ₹ 1,35,727 and ₹ 1,01,373 per ha, respectively, in the West U.P. The higher cost of production for plant crop was primarily due to seed cost, fertilizers and labour wages. The cost of production (Cost C) for plant and ratoon was ₹ 1,25,374 and ₹ 1,04,525 per ha, respectively, for U.P. The cost of production in the West U.P. was higher as compare to central and the East U.P. Amongst factors of production and purchase inputs, seed, labour wages and land revenue had a lion's share in Cost C. It was observed that the hired labour wage rates and mechanical power have increased. Some respondent's farmers had adopted mechanization to address labour constraints for various intercultural operations. They have improved per unit sugarcane productivity through adoption of early maturing varieties, intercropping in autumn planted cane, trench planting method, wider row spacing, planting of single bud/ two bud sets in place of three bud sets, skip furrow irrigation for higher yield per drop of water. Progressive farmers used sugarcane cutter planter, small tractor or multi-purpose power tillers for interculture operations to minimize costs. Sugarcane harvesting, loading and transport charges in the West U.P. were also higher as compared to the East U.P.

Sugarcane planting with single/two buds setts in pair row and wider spacing

Adoption of cane seed, irrigation water and labour saving techniques

The BC ratio, net return on Cost A and Cost C basis from cane plant and ratoon crop was worked out (Table 9.4). Net income from sugarcane plant and ratoon in the western U.P. was better than central and the eastern U.P. Net income on Cost C for plant and ratoon was ₹ 73,174 and ₹ 59,940 per ha respectively in western U.P. The higher net income of farmers associated with better cane productivity 76.3 tonne/ha as compare to 61.6 tonne/ha in ratoon. Sugarcane productivity gaps in the West, central and east Uttar Pradesh in plant and ratoon were due to poor ratoon management and low input use. Study concludes that sugarcane production in the West Uttar Pradesh was remunerative as compared to central and the East U.P.

Economics of sugar and co-products processing

The cost of sugar processing includes expenses incurred by the sugar mills on raw material procurement and various conversions cost, overhead expenses of mills for processing sugarcane into sugar and co-products. Farmers have to supply cane to the sugar mills through cane cooperative societies as they do not have direct link with sugar mills. The cost of sugar production in U.P. also varies from ₹ 28,780 to ₹ 38,436/tonne with ex-mill sugar price ₹ 31,000 - 37,000 per tonne during year 2015-16 in standalone, integrated sugar-energy complex owned by cooperative or private sector. Cost of cane procurement has a lion's share of 80-85 per cent in sugar processing expenses. Average cane crushing capacity of selected sugar mills varied from 2,750 to 15,000 TCD in U.P. The highest sugar recovery of 12.40 per cent was achieved by M/s Seksaria Biswan Sugar Mill with the crushing duration 144 days during crushing season 2015-16. This sugar mill has crushed 9.56 lakh tonne sugarcane and bagged 1.184 lakh tonne sugar during year 2015-16. Similarly, Dwarikeshnagar, Bundaki, Dalmia Sugar Mills, Nigohi and Kisan Cooperative mills, Nijibabad also achieved sugar recoveries from 11.42 to 12.12% during

Table 9.4. Economics of sugarcane production in sub-tropical States in 2015-16

Items/Particulars	Western U.P.		Central U.P.		Eastern U.P.		Overall U.P.	
	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon
Yield (tonne/ha)	76.3	61.6	70.8	57.3	60.4	51.4	69.2	56.8
Gross return (₹/ha)	203721	160776	193992	147261	164892	126444	187535	144827
Cost of sugarcane production (₹/ha)								
Operational Cost A	88207	58064	80436	57971	75942	58255	80832	58097

year 2015-16 (Table 9.5). These sugar mills have initiated steps to ensure minimal level of extraneous material with cane for minimizing cut to crush delay and reduced the post harvest sugar losses in processing. Modernization and use of upgraded technologies in sugar energy complexes also go a long way in increasing sugar recovery and make sugar sector competitive. Sugar and co-products production varies drastically in sugar mills owned by cooperative or private sector. There are fluctuations in cane supply to the sugar mills which affects their crushing duration, economic feasibility, profitability and cane price payment situation.

Early maturing variety (EMV) Co 0238 has recorded maximum increase in all the surveyed sugar mills. In some sugar mills such as Biswan, Bundaki and Nigohi, Co 0238 has 60-80 per cent of acreage under the EMV. Area under this variety was 4.0 - 4.5 lakh ha in U.P during sugarcane production season 2015-16. It is concluded that the EMV has a role in enhancing the sugar recovery in U.P. Subtropical region experienced drought, no cane lodging and ideal climatic conditions for sugar accumulation during winter which may be a reason for higher sugar recovery during sugar season 2015-16 in U.P. Better sugar recovery and reasonable high sugar prices have undoubtedly improved the profitability and financial feasibility of majority of sugar mills in sub-tropical region. Sugar sector may be made economically viable in long term in this tumultuous phase through product diversification such as bioethanol, Co-generation, bio-fertilizer, bio-organics like bio-plastic, pulp and paper *etc.* the Government of India made several policy amendments and has opened avenues for ethanol and power co-generation from sugarcane. It is an opportunity to harness the potential of this crop as bio-energy apart from being the source of sugar and jaggery. Keeping in view the demand of petroleum products in U.P. and implementation of 10-20 per cent ethanol blending with petrol by year 2017, the sugar mills should be equipped to produce ethanol from heavy molasses and to switch over to ethanol production in the situation of excess sugar production for maintaining the domestic sugar prices. The timely cane price payment to the farmers through cooperative societies or directly to the cane farmers should be ensured by the mills. Majority of the sugar mills had adopted modern ICT tools such as computer based sugarcane network system for dissemination of their advisory services, status of cane supply tickets and price payment *etc.* Future of sugar mills in U.P. depend on profitable and sustainable technological innovations, their adoption infrastructural development and also on government supportive policies. The technological breakthroughs may lead to better sugar production per drop of water. Linking of sugarcane prices with revenue realization from sugar and co-products; longer duration cane area reservation to sugar mills may aid the state to regain its past glory for welfare of the farming community.

Development of data mining and presentation tools in sugarcane

The project was started with the objective to provide a platform for analytical exploration of

Table 9.5. Sugar recovery and acreage under early maturing varieties in selected sugar mills

Sugar Mill	Sugar recovery (%)			Proportion of EMV (%)		
	2013-14	2015-16	Difference	2013-14	2015-16	Difference
Seksaria, Biswan, Sitapur	10.17	12.40	2.23	29	64	35
Dwarikesh, Bundaki, Bijnore	10.49	12.11	1.62	31	67	36
Dwarikesh, Faridpur, Bareilly	9.65	11.16	1.51	18	35	17
Uttam, Barkatpur, Bijnore	9.42	11.54	2.12	12	60	48
DSM, Dhampur, Bijnore	9.70	11.36	1.66	08	32	24
DSM, Mirganj, Bareilly	8.89	9.95	1.06	19	57	38
Dalimia Sugar Ltd., Nigohi	10.20	11.94	1.74	39	76	37

information in sugarcane domain. In order to achieve these objectives, initiatives has been taken to develop a web portal which will be the central platform to access various categories of information in sugarcane domain. Structure of portal has been designed with categorization of information in four domain *viz.*, research, extension, industry, public and miscellaneous.

Modules under research domain will provide information about all aspects of sugarcane and sugar research. Research publications, technologies, network, advisory, manuals, vocabulary, expert links, *etc.* will be various categories of information provided under research domain. Stakeholders requiring research information will be benefitted from this domain.

Information under extension domain will cater the information requirements of farmers and extension workers in agriculture, in general, and sugarcane, in particular. Package of practices, production/protection advisories, success stories, FLDs, ITK, manuals, videos, *etc.*, will be provided through a set of modules under this category of portal.

Industry domain will fulfill information requirements of sugarcane and sugar industry in the form of sugarcane production/utilization database, training, policies, forecasting, resources, scheduler, *etc.*

Information of general public will be provided through public domain modules. Modules will be added to provide general information about sugarcane facts, health benefits, history, education/training *etc.*

Miscellaneous domain will incorporate sugarcane/sugar news, jobs, learning options, statistical data about sugarcane and sugar.

Further, modules have been developed to provide links to sugarcane/sugar facts, nutritional benefits, and historical aspects under this portal.

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All India Coordinated Research Project on Sugarcane

The Indian Council of Agricultural Research sanctioned the All India Coordinated Research Project on Sugarcane (AICRPS) in 1970 as a Fourth Five Year Plan Project to intensify research on important problems of sugarcane having regional or local significance with its headquarters at the Indian Institute of Sugarcane Research, Lucknow. The project aims at pooling the research resources of the country involving State Agricultural Universities and Sugarcane Research Stations at Central and State Institutes in a national grid for addressing the regional and national problems. Since 1997, there are 22 regular centres located in 16 States of the country, Besides, there are 14 voluntary centres.

Regular Centres of All India Coordinated Research Project on Sugarcane

Mandate

1. Evaluation of locally adapted sugarcane varieties with improved yield and quality as well as resistance to biotic and abiotic stresses.
2. Development of package of practices for higher

Salient Research Achievements

Crop Improvement

Zonal Varietal Trial : In Peninsular Zone, the entry Co 09004 (early) was found promising. In East Coast Zone, the entry CoC 10337 (mid late) was found more stable than the widely adapted mid late maturing varieties Co 7219, CoV 92102 and Co 86249 of the zone. In North Central & North East Zones, BO 153, CoP 08436, CoSe 09452 and UP 09453 in early maturity group were found promising. BO 153 and CoP 08436 were found more stable than the widely adapted early maturing variety CoSe 95422 of the zone. In mid late maturity group, CoP 09437 was found more stable than the widely adapted mid late maturing varieties BO 91 and CoSe 92423 of the zone. In North West Zone, CoPb 09181 (early) and CoPb 09214 (mid late) were found promising. CoPb 09214 was found more stable than the widely adapted mid late maturing varieties CoS 767, CoS 8436 and CoPant 97222 of the zone.

Besides, the stability of varieties under Advanced Varietal Trials has been analysed using simultaneous selection criterion for selecting genotypes with high yield and stability by the application of Additive Main Effects and Multiplicative Interaction (AMMI) model.

Evaluation and identification of climate resilient ISH and IGH genetic stocks

A new experiment has been initiated this year. Evaluation of ISH & IGH genetic stocks for drought tolerance is being performed at Padegaon, Anakapalle, Faridkot and Karnal (SBI) centres, while evaluation for waterlogging tolerance at Kolhapur, Vuyyuru, Motipur (IISR) and Pusa centres.

Fluff Supply Programme : During the year, Breeders

Crop Production

Agronomic evaluation of promising sugarcane genotypes showed that recommended doses of fertilizers were sufficient for achieving higher cane and sugar yield. However, at Pantnagar and Uchani in North West Zone, Pusa in North Central Zone, Buralikson in North East Zone, Padegaon and Thiruvalla in Peninsular Zone and Cuddalore centres in East Coast Zone, 125% of recommended doses of fertilizers promoted significantly higher cane yield of new varieties.

Response of NPK, micro- and secondary nutrients in varied agro-ecological situations revealed that the application of recommended doses of NPK along with sulphur, zinc and iron promoted significantly higher cane yield. Application of soil test based fertilizers was necessary at few centres *viz.*, Faridkot in North West Zone, Thiruvalla, Mandya and Navsari in Peninsular Zone and Nayagarh and Anakapalle in East Coast Zone. Manganese was necessary for application at few locations (Sriganganagar, Uchani, Navsari and Cuddalore).

For enhancing sugarcane productivity and profitability under wheat-sugarcane cropping system in sub-tropical zones, wheat sown in November by FIRB method and sugarcane planted in furrows in February or March was the most remunerative at Faridkot and Lucknow. However, in Pantnagar, Uchani, Pusa, Padegaon and Powarkheda, significantly highest cane equivalent yield was recorded under autumn planted sugarcane intercropped with two or three rows of wheat between two rows of sugarcane.

To accelerate germination in sugarcane by priming of cane node, conventional 3-bud planting without priming was found to give higher germination as well as significantly higher cane yield at nine centres. At seven centres, priming cane node with cattle dung + cattle urine + water in 1:2:5 ratio was found better. As compared to conventional planting with 3-bud setts, planting of cane nodes substantially reduces the quantity of seed cane.

At Faridkot, surface drip and at Lucknow centre

Application of FYM @ 20 t/ha + inorganics based on soil test promoted significantly higher cane yield and NMC followed by application of FYM @ 10 t/ha + biofertilizer (*Azotobacter* + PSB) + inorganics based on soil test. The latter treatment was more cost effective as 10 tonne of FYM can be substituted by the bio-fertilizers.

Plant Pathology

New isolates of red rot pathogen were tested on 14 differentials for identification of new pathotypes. At Kapurthala, Karnal, Shahjahanpur and Coimbatore, indication of new pathotypes has been reported. The finding needs further confirmation at zonal testing centres.

A total of 100 entries were evaluated for red rot, smut, wilt and yellow leaf disease resistance. Red rot reaction ranged from moderately resistant to highly susceptible by plug and nodal cotton swab method. Several varieties were found resistant to smut, wilt and yellow leaf disease. At four centres, 80 ISH clones were evaluated for red rot resistance.

Survey reports indicated prevalence of red rot in all the sugarcane growing States except Maharashtra, Karnataka, Madhya Pradesh and Rajasthan. High incidence of red rot was recorded in Haryana, Andhra Pradesh and Tamil Nadu on old varieties, in general. Smut incidence was, in general, lower except in Andhra Pradesh. Wilt incidence was relatively higher in Tamil Nadu and Andhra Pradesh. Grassy shoot disease was severe in Haryana, western and central Uttar Pradesh and Andhra Pradesh. Higher incidence of rust was recorded in Maharashtra, Karnataka and Andhra Pradesh. Sugarcane yellow leaf disease incidence was higher in Andhra Pradesh. Brown spot disease is gaining importance in Maharashtra only. Severe incidence of mosaic was recorded in Assam.

For management of brown rust disease, mancozeb 75 WP (0.3%), propineb (0.25%), propiconazole (0.1%) and triadimefon (0.1%) were individually most effective fungicides.

For evaluation of varieties against brown rust, methodology for inoculating pathogen is being

Pune, Kolhapur and Anakapalle centres. Epidemiological studies indicated that the disease was favoured by high humidity, high rainfall and lower temperature. The disease appeared at the onset of monsoon. At Uchani and Anakapalle, the disease was effectively managed by soaking setts overnight in carbendazim (0.10%) followed by foliar spray of carbendazim (0.05%) three times at fortnightly intervals soon after the appearance of disease.

Entomology

One hundred zonal varieties were evaluated against major insect pests. Grades of insect-pest infestation, *viz.*, less susceptible, moderately susceptible and highly susceptible on varieties were recorded.

The parboiled rice medium was found simple and cost effective for mass multiplication of the bioagent, *Beauvaria bassaiana*.

Survey reports indicated high incidence of early shoot borer in Haryana, Uttar Pradesh, Maharashtra, Karnataka and Andhra Pradesh; black bug in Haryana; Pyrilla in Haryana, Bihar and Andhra Pradesh; root borer in Haryana, Uttar Pradesh, Maharashtra and Gujarat; stalk borer in Uttar Pradesh alone; mealy bug in Maharashtra and Karnataka; scale in Maharashtra and Andhra Pradesh; white fly in Gujarat and Andhra Pradesh; internode borer in Karnataka; and red mite in Andhra Pradesh. During the year, top borer incidence was relatively lower across the country.

Monitoring of insect-pests and bio-agents in sugarcane agro-ecosystem showed that the bioagents of early shoot borer, top borer, stalk borer, Pyrilla, root borer, whitefly, woolly aphid, internode borer and mealy bug were prevalent in sugarcane crop agro-ecosystem.

Bio-efficacy of insecticides against mealy bugs in sugarcane showed that treatment of setts with imidacloprid 70 WG/SP @ 25 g a.i./ha effectively reduced intensity of mealy bug at Navsari.

Population of early shoot borer, top borer, internode borer and stalk borer was studied through pheromone traps. The number of captures was

planting or chlorantraniliprole 18.5 SC @ 375 ml/ha applied as spray after 30 and 60 days of planting was found most effective against early shoot borer.

Technologies developed and recommended

- **Identification of sugarcane varieties**

During meeting of Variety Identification Committee, held at the Krishi Bhavan, New Delhi on 10th March, 2016, two varieties CoFb 08212 (early) for North West Zone and CoP 09437 (Midlate) for North Central & North East Zones, were identified for release.

- **Agrotechnologies**

I. **Response of sugarcane crop to different plant nutrients in varied agro-ecological situations :** Application of Zn @ 5 kg/ha and S @ 40 kg/ha along with NPK every year to sugarcane plant crop was recommended for subtropics, while for tropics, the application rate of Zn and S was 10 and 60 kg/ha along with NPK, respectively.

II. **Enhancing sugarcane productivity and profitability under wheat-sugarcane cropping system:** Where moisture is not a limiting factor, intercropping of sugarcane and wheat (1:2 or 1:3) with sugarcane in furrow and wheat on raised bed can be taken. Where terminal heat is a problem, sequential sowing of wheat in November/December in FIRB followed by sugarcane planting in furrows in February/March was the best.

III. **Priming of cane node for accelerating germination :** For Peninsular Zone, where soil moisture does not deplete rapidly, planting of primed cane node may be used as planting material and for North West Zone, conventional planting of 3-bud setts may be continued.

- **Disease & Insect-pest management**

I. **Management of brown rust of sugarcane :** Two sprays of propineb (0.2%) or mancozeb 75 WP (0.3%) at 15 days intervals from the initiation of the symptoms were found effective against the disease. The cost benefit ratio analysis of different treatments indicated the highest C:B ratio (1.02) by Mancozeb 75 WP @ 0.3%

controlled mealy bug of sugarcane.

Group Meeting of AICRP on Sugarcane

The Group Meeting of All India Coordinated Research Project on Sugarcane was hosted by the Rajendra Agricultural University, Pusa (Bihar) on December 15-16, 2015. The Opening Session was held under the Chairmanship of Dr. J.S. Sandhu, DDG (CS), ICAR, New Delhi. On this occasion, Dr. A.K.P. Singh, Vice-Chancellor, RAU, Pusa was the Chief Guest. Dr. J.P. Upadhyay, Director of Research, RAU, Pusa welcomed the participants. He gave the detailed account of sugarcane cultivation in Bihar. He also highlighted the achievements of SRI, Pusa. Dr. O.K. Sinha, Project Coordinator (Sugarcane) presented the annual progress report of AICRP on Sugarcane for the year 2014-15. Dr. Bakshi Ram, Director, ICAR-SBI, Coimbatore, apprised about the increasing area under the variety Co 0238 in Uttar Pradesh, Haryana and Punjab. He remarked that by 2050, there would be requirement of 50 million tonne of sugar for internal consumption which could be achieved by the appropriate blending of varieties. He suggested that during excess cane production, sugarcane juice may be diverted for ethanol production.

Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow briefly narrated the global production of sugarcane and sugar. He mentioned that sugarcane is now becoming a preferred crop not only for sugar production, but also for bio-fuel, green energy and other by-products like bio-plastics, bio-polymers *etc.* Bio-ethanol from sugarcane juice, baggasse and cellulosic material could meet out the increasing requirement of ethanol for blending in petrol. Dr. A.K.P. Singh, Vice-Chancellor, RAU, Pusa, in his inaugural address, focussed on the sugarcane research and development programme in Bihar and constraints in sugarcane cultivation. He laid emphasis on mechanization which can substantially reduce the cost of sugarcane cultivation.

Dr. J.S. Sandhu, DDG (CS), ICAR, New Delhi and Chairman of the session remarked that climate change is becoming a serious problem in most of the crops. He laid emphasis on developing sugarcane varieties tolerant to climatic change and abiotic stresses, which can be accomplished by making more

Pandey, Director, SRI, Pusa.

A joint session was held under the Chairmanship of Dr. J.S. Sandhu, DDG (CS) for identifying constraints in sugarcane productivity. Scientists from different states apprised the major constraints in achieving higher cane productivity.

The concurrent technical sessions of Crop Improvement, Crop Production, Plant Pathology and Entomology were held to review the annual progress of research work and formulation of technical programme for 2016-17.

Zonal Breeders Meet

Zonal Breeders Meet was organized by the All India Coordinated Research Project on Sugarcane at the EID Parry India Ltd., Nellikuppam, Tamil Nadu on 29th January, 2016. Sugarcane Breeders from different centres in East Coast Zone, North West Zone, North Central and North East Zone participated in the meeting. Dr Manjunatha S. Rao, Associate Vice President, EID (Parry) India Ltd., welcomed the participants. He briefly mentioned the research activities being undertaken by the EID Parry India Ltd., at Nellikuppam and Pugalur centres.

Mr. M. Balaji, Senior Associate Vice President gave the glimpses of the sugar mill. He informed that the factory was one of the oldest sugar mills in the country and time to time, it was upgraded with the latest technologies. The modern mill has 6,500 TCD crushing capacity, 120 t/day of sugar refinery, 24.5 MW of power production and 75 KLD of alcohol. The factory collaborated with 20,000 farmers in the process. The crushing duration of the mill had come down from 313 days during the season 2012-13 to 230

sugar recovery will benefit the mill significantly. The mill is also unique in achieving zero discharge as every part of the cane was converted into a useful product and no waste is let out from the factory.

Dr O.K. Sinha, Project Coordinator, AICRP on Sugarcane, in his introductory remarks, thanked the management of EID Parry for conducting the Zonal Breeders Meet at Nellikuppam. The forum also had given more opportunity to interact with the breeders closely to sort out the technical programme for 2016-17. Zonal Breeders Meet was conducted first time by combining the four zones (NWZ, NC & NEZ and ECZ) representing both tropical and subtropical zones. Among the five zones, East Coast Zone is the only zone having coastal eco-system under which sugarcane is being cultivated. The zone has major problems like waterlogging and high humidity. Most of the entries in the ZVT were showing susceptibility to red rot and pathologists must work out the precision screening strategies for identification of red rot resistant clones. Recently released variety *viz.*, CoOr 03151 as well as CoA 92081 have shown resistance to red rot and hence can be used as parents for developing red rot resistant varieties. He informed that the meeting would be discussing on the promotion of entries from IVT to AVT and finalization of technical programme.

Dr. Bakshi Ram, Director, ICAR-Sugarcane Breeding Institute, Coimbatore and Principal Investigator, Crop Improvement, AICRP(S) in his presidential address informed that the Vision 2050 document of SBI projected the sugar requirement of 48 million tonne and the present production level is around 28 million tonne. With the available technologies at present, it might not be possible to reach the target and therefore, breakthrough technologies are required. At present, varietal replacement is very poor and if the new variety does not record more than 20% yield improvement, neither the farmer nor the sugar mill would be interested in the new variety. ICAR-SBI, Coimbatore had initiated a new research progarmme on true seed technology which had several advantages including saving of huge quantity of cane planting material. Already the Institute had made several crosses involving inbreds and the progenies would be evaluated for cane yield factory area could be integrated in expanding true seed technology. In the varietal development front, he expressed his concern that many released varieties were not spreading fast in the zone. There should not be any restriction by a State to introduce a released variety developed by other States within the zone. The standards used in the ZVT had deteriorated and expression was poor in the trials and the centres should use healthy seed material for the standards. The clones proposed by some centres like Cuddalore show susceptible reaction to red rot in the IVT itself. Hence, red rot testing should be done perfectly as per the procedure adapted by AICRP(S).

Technical session of the Zonal Breeders Meet was chaired by Dr. Bakshi Ram, Director, ICAR-Sugarcane Breeding Institute, Coimbatore. 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 ten entries evaluated in IVT (E), four entries *viz.*, Co 12026, Co 12027, CoLk 12203 and CoPant 12221 were selected based on juice sucrose (%) at 10th month, red rot resistance and field stand. These five entries will be evaluated in AVT (E) I Plant during the year 2016-17.
- Among the 15 entries tested in IVT (ML), six entries namely, Co 12029, CoH 12263, CoLk 12205, CoPant 12226, CoPb 12211 and CoS 12232 were selected for conducting AVT (ML) I Plant trial during the year 2016-17.
- In North Central Zone, five entries were evaluated in IVT (E) and three entries *viz.*, CoLk 12207, CoP 12436 and CoSe 12451 were selected for testing in AVT I Plant (Early) trial during the year 2016-17.
- Among the six entries tested in IVT (ML), four entries namely, CoLk 09204, CoLk 12209, CoP 12438 and CoSe 12453 were selected for conducting AVT (ML) I Plant trial along with three standards during the year 2016-17.
- In East Coast Zone, eight entries were evaluated in IVT (E) and five entries *viz.*, CoA 13322, CoA

rot and cane stand, out of eight entries tested in IVT (ML), three entries namely, CoA 12324, CoC 13339 and CoOr 13346 were selected. Along with these three entries, the entry CoA 11326 which was under multiplication in the centres during 2015-16 would be also included and a total of four entries would be tested in AVT (ML) I Plant trial during the year 2016-17.

- Project Coordinator may write to UPCSR on significant difference reported in the red rot reaction of the entries compared the red rot rating reported by other centres of NWZ.
- Some of the entries showed poor juice quality in IVT stage itself although good juice quality was presented while proposing the variety two years back. The proposing centres may take care on the juice quality while proposing new entries.
- Shortage of seed material in Co 13033, Co 13034 and CoPb 13181 was intimated by Lucknow. Karnal centre will supply sufficient seed material to Lucknow.
- Shahjahanpur will supply CoS 11232 to Lucknow centre which reported shortage of seed material due to infection by wilt.
- The best entries identified from the two plant and one ratoon crops in AVT will be multiplied by the centres for at least three years for inclusion as the latest check when the variety is notified for the zone.
- The latest released early variety Co 05009 and mid late variety Co 05011 will be supplied by Karnal centre to all participating centres of NWZ.
- CoLk 12207 was reported to be highly susceptible to red rot only at Motipur centre which may be checked again.
- CoLk 94184 will replace BO 130 as early standards from 2017-18 onwards in NC & NEZ and the seed material of CoLk 94184 will be supplied by Motipur to all centres of NC & NEZ.
- Poor juice quality of entries under evaluation in ECZ was discussed at length. After a detailed discussion, it was decided to complete the selection in seedling population during the 2nd fortnight of December for selection of high sucrose clones.
- The latest released mid late variety Co 06030 will be supplied by Coimbatore to all participating centres of ECZ.
- All the four centre which are evaluating ISH/IGH clones for drought tolerance will plant new Plant I crop trial with all the 27 entries.
- Co 6907 and Co 7219 are removed from standards in early and mid late trials, respectively in ECZ from the year 2016-17 onwards.
- ICAR-SBI, Coimbatore will send a format for identification and evaluation of Zonal Crosses to all the fluff receiving centres.

IP Mana

- A pate
  planting material, its packaging, transportation and certification" has been filed with the Indian Patent Office, New Delhi and FER is awaited

Delhi as per details given below:

Trade Marks Registry

INTELLECTUAL PROPERTY INDIA

Registered Trade Marks and Application Status Information

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Guideline for Use

TM Application No.	3253310
Class	99 [99 Indicates Multiclass Application]
Appropriate Office	DELHI
State	UTTAR PRADESH
Country	India
TM Applied For	IISR
TM Category	TRADE MARK
Trade Mark Type	DEVICE
User Detail	26/01/2012
Certificate Detail	Certificate No Date
Valid upto/ Renewed upto	
Proprietor name	(1) ICAR-INDIAN INSTITUTE OF SUGARCANE RESEARCH[189634 Single Firm
Proprietor Address	RAIBARELI ROAD ,P.O. DILKUSHA,LUCKNOW-226002
Goods & Services Details	[CLASS 1] CLASS 1 IN RESPECT OF CHEMICALS SUCH AS BIOCIDES, A CHEMICAL FORMULATION TO CONTROL POST-HARVEST LOSSES IN SUGARCANE, ETHEPHON, A GROWTH ENHANCER, ENZYME EFFECTORS VIZ., DIVALENT CATIONS AND PLANT GROWTH REGULATORS (PGRS) AND DINITROSOCIFROL (DNC) AS CANE RIPENER USED IN INDUSTRY, SCIENCE, AGRICULTURE, HORTICULTURE AND ALLIED INDUSTRIES; MANURE IN THE NAME OF IKSHUBACK, A MICROBIAL CONSORTIA, AND CLARIFICANT FOR SUGARCANE JUICE [CLASS 7] CLASS 7 IN RESPECT OF SUGARCANE PLANTING INTERCULTURING AND HARVESTING MACHINES FOR MECHANIZING THE SUGARCANE CULTIVATION, SUGARCANE INTERCULTURING AND COMPANION CROPPING EFFICIENT MACHINES AND HARVESTING & DETRASHING MACHINES. [CLASS 8] CLASS 8 IN RESPECT OF SUGARCANE HAND TOOLS AND IMPLEMENTS SUCH AS FURROW DEEPENING TOOL, SETT CUTTING MACHINE, MANUAL SUGARCANE HARVESTER, SUGARCANE STRIPPER, BUD CHIP SCOOPING DEVICE [CLASS 30] CLASS 30 IN RESPECT OF VALUE ADDED JAGGERY, QUALITY SUGARCANE JAGGERY AND CONFECTIONERIES [CLASS 31] CLASS 31 IN RESPECT OF SUGARCANE SEEDS

Technology Management

ICAR-Indian Institute of Sugarcane Research has signed Memorandum of Understanding (MoUs) with private firms to commercialize following Institute technologies:

Name of Technology	Name of Contracting Party	Date of Licensing	Revenue Earned (₹)
Sugarcane planter and other equipments	Orpet Agro Industries, Muzaffarnagar	27.05.2015	30,000/-
Sugarcane planter and other equipments	Kisan Agro Industries, Saharanpur	08.09.2015	30,000/-
IISR Model Jaggery Unit	Shri Prabhat Jha, West Champaran	22.02.2016	30,000/-
Sugarcane Process Machineries	KS Projects and Process Engineers Pvt. Ltd., Lucknow	04.02.2016	30,000/-
IISR Model Jaggery Unit	ARB Organic Jaggery, Hisar	22.02.2016	30,000/-
IISR Model Jaggery Unit	Sri Radha Krishan Jan Kalyan Sansthan, Modinagar, Ghaziabad	07.03.2016	30,000/-
Sugarcane Process Machineries	Patel Manufacturing Company, Gujarat	05.03.2016	30,000/-

Awareness Programme

An awareness programme on Intellectual Property and Technology Management was organized to sensitize the sugarcane scientists in the Institute on November 16, 2015. The programme was attended by 33 scientists. One external expert was the main speaker on the occasion. A patent tool box for sugarcane was prepared and using this tool box the creativity of the scientists was indexed. An IP Expert delivered the lecture on IP Management with special emphasis on copyrights to all the Scientists of Institute.

Other activities

- A proforma for reviewing of MoAs has been prepared and sent to all contracting parties having the agreement with the Institute.
- A Technology and Machinery Demonstration *Mela* was organized on March 18, 2016.
- An undertaking on "No Plagiarism" is being obtained on every research paper being submitted for publication to PME Cell of the Institute.
- IP issues have been considered in MoUs signed with SAUs and other Universities for capacity building of researchers, in providing research lab facilities or in guiding the M.Sc. /Ph. D Theses/ research work of the students.

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Outreach Programmes and Transfer of technology

Outreach programmes of the Institute consist of providing services to distantly located cane growers, sugar mills and other stakeholders who do not have direct and easy access to the Institute services such as trainings and exposure to the Institute technologies. In addition to delivering services, outreach programmes provide an educational role and raise the awareness of existing services. Awareness and entrepreneurship development programmes, assessment of technologies and frontline demonstrations in farmers' fields, prototype feasibility testing, *kisan goshthies*, field visits and adoption of villages in different districts of Uttar Pradesh, Bihar and Maharashtra constituted the Institute outreach programmes during the year, as per details given below:

Breeder seed production in sugar mill areas

Breeder seed production of six varieties *viz.*, CoLk 94184, Co 0232, CoP 9301, Co 0238, Co 0118 and BO 153 was carried out in 46 ha at Harinagar, Hasanpur and Narakatiaganj sugar mill areas in Bihar state. About 24000 qt. of breeder seed was produced for distribution to farmers.

Assessment of sugarcane cultivation machines (RMD and RBS cum planter) on farmers' fields

During three years *i.e.* from 2012-2015, a total of 97 demonstrations on Ratoon Promoter machine developed by ICAR-IISR were conducted in Biswan sugar mill (Sitapur) zone area to promote the adoption of this machine by the farmers. Demonstrations on this machine was conducted in 20 villages covering 71.89 ha ratoon area (39.52 ha under ratoon promoter and 32.37 ha under conventional practices, Figure 12.1). The average yield obtained for demo plots, was 69.32 t/ha which was 15.17% higher than the yield of 60.19 t/ha obtained in conventional plots (Fig. 12.2). In all demonstration plots, ratoon promoter was operational and maintenance aspect of the machine to the cane development staff of the sugar mill and beneficiary farmers. Data on performance of machine was collected by conducting personal interview of cane growers. The analysis of collected data indicated that 86.67, 73.33, 93.33, 86.67, 40.00 and 40.00 per cent beneficiary farmers' were satisfied with the operations like stubble shaving, off barring, deep tilling, earthing up, fertilizer application and chemical application, respectively. At the same time, saving of average 30-40 labours/ha and net saving in cost to the tune of ₹ 4,500-6,000/ha was recorded in demo plots over conventional plots. With 9.13 t/ha more yield in demo plots farmers also earned extra revenue of ₹ 25,564/ha, in addition to saving in cost of ratoon crop raising with Ratoon promoter. Out of total beneficiary farmers, about 47% farmers wish to adopt this machine very soon and rest of the farmers either do not want to adopt (20%) or yet not decided (33%) in this regard. However, 60 % farmers opined that higher cost of the machine is major obstacle in adoption of this machine.

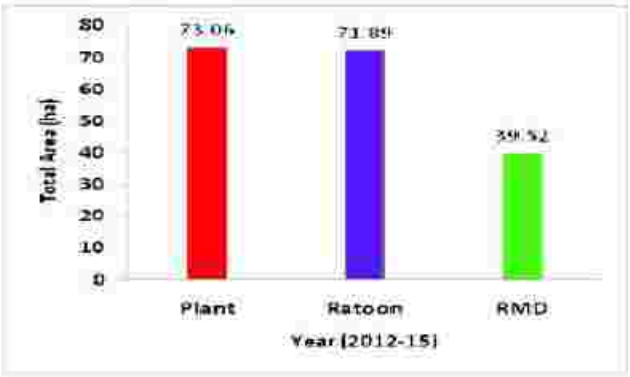

Fig. 12.1. Area under plant cane, ratoon and RMD

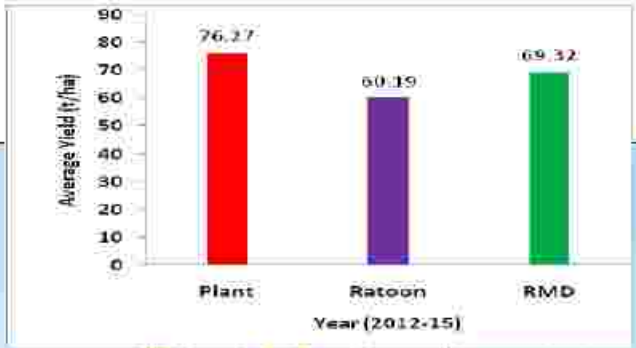

Fig. 12.2. Average cane yield for the year 2012-2015

Adoption of villages under " *Mera Gaon Mera Gaurav*" scheme

"Mera Gaon Mera Gaurav", an innovative scheme of ICAR is being implemented by the groups of scientists of ICAR-IISR, Lucknow. The Institute constituted 13 multidisciplinary teams (each of four scientists) to promote the direct interface of the scientists with the farmers to hasten lab to land process. Dr. R.S. Dohare, Principal Scientist (Agricultural Extension) is the Nodal Officer at the Institute level for implementation of the scheme. The team of scientists selected 63 villages in five districts of Uttar Pradesh *viz.*, Sitapur (38), Faizabad (10), Raebareli (5), Barabanki (5) and Hardoi (5). Based on baseline survey in the selected villages, the problems of the farmers to be addressed were prioritised. The scientists offer farm advisory services in agriculture and other allied areas by paying their personal visits at home and field to the farmers. The mobile user farmers have also been identified for making delivery of farm advisory more rapidly in case of immediate concern among the farmers in selected villages. The team of scientists collected soil samples at farmers' field and analysed in the Institute laboratory. A total of 310 Soils Health Cards with specific recommendations have been provided to the farmers so far. The activities are being continued in the villages for harnessing benefits of improved farm advisory and technological backstopping to the farmers as well as to personnel of line development departments functioning in the villages.

Institute scientist inspecting farmers fields under *Mera Gaon Mera Gaurav* scheme

Adoption of trench planting on the farmer's field

Frontline demonstration of IISR deep furrow sugarcane cutter planter

Frontline demonstrations of IISR tractor operated deep furrow sugarcane cutter planter were conducted at farmers fields in Muzaffarnagar, Bahraich (U.P.) and East Champaran (Bihar) in 10.4 ha field covering 20 farmers. Effective field capacity of the planter was 0.16-0.20 ha/h. Cost of planting was reduced by 50% as compared to conventional method of planting.

Frontline demonstrations of IISR tractor operated paired row trench planter

Frontline demonstrations of IISR tractor operated paired row/trench planter was conducted at farmers fields in Sitapur district in 2.0 ha area. Equipment is used to plant one pair of sugarcane at 30 cm row spacing in deep and wide furrow (trench). The row spacing between the subsequent pairs could be varied by maintaining the spacing between the tractor tyre and previously planted rows. Cane was planted under 30:120 cm row geometry. Effective field capacity of the planter was 0.20 ha/h. Cost of planting was reduced by 50% as compared to conventional method of planting.

Prototype Feasibility Testing (PFT) of tractor operated reaper binder

Tractor operated reaper binder performs

Quality jaggery making services in Bihar

A model jaggery plant was established at IISR Regional Centre, Motipur (Bihar). The unit was visited by Hon'ble Minister of Agriculture and Farmers' Welfare, Sh Radha Mohan Singh ji who inaugurated a Farmers' Training Home and Jaggery Training Unit. Dr Trilochan Mohapatra, DG, ICAR and Secretary, DARE, Govt of India and DDG (CS), ICAR also graced the occasion. The unit would cater to the entrepreneurial developmental needs of jaggery producers in the state of Bihar.

Hon'ble Minister of Agriculture & Farmers Welfare, GoI addressing farmers at IISR RC, Motipur

Field day - cum farmers' interaction programme in Pravaranagar area of Maharashtra

An extensive sugarcane field visit was carried out by IISR scientists in the sugarcane factory command area of PDVVPSSK Ltd., Pravaranagar and interacted with a large number of farmers. In this field day-cum

different places, the Director stressed the need for enhancing sugarcane productivity by improving soil productivity by way of applying organic manures through cane trash, SPMC, green manuring, intercropping with pre-seasonal sugarcane. Farmers of the area have started adopting intercropping with pre-seasonal sugarcane, trash mulching *etc.*, for enhanced productivity and profitability. ICAR-IISR Biological Control Centre of Pravaranagar (MS) is being strengthened to provide insect pest and disease management services and adequate backstopping as per need of Maharashtra sugarcane farmers.

Extension activities at ICAR-IISR Biological Control Centre, Pravaranagar (MS)

Mass multiplication and field colonization of *Trichogramma chilonis* and distribution against early shoot borers in Pravaranagar Area of Maharashtra

Mass multiplication and distribution of *Trichogramma chilonis* (Tricho cards) against sugarcane borers were carried out in different villages around Pravaranagar. Mass multiplication of *Trichogramma chilonis* Ishii was done on eggs of rice moth, *Corcyra cephalonica* Stanint in the laboratory. Trichocards are prepared from UV treated host eggs. Trichocards were distributed to the farmers of the area.

Entrepreneurship development for sugarcane seed production and multiplication

During the year 2015-2016, seed cane crop of seven selected varieties *viz.*, CoLk 94184, CoLk 9709, CoPk 05191, Co 0118, Co 0238, Co 05011 and CoH 128 was sown on factory farm and farmers' fields in mill zone area. A total of 40 seed cane plots in 7.70 ha area was maintained in the five villages in the command area of sugar mill (Table 12.1). The crop was sown with recommended practices for seed cane crop raising.

The average yield obtained for seed cane crop of different varieties raised during last season *i.e.* 2014-2015 were 110, 115, 88, 92 and 89 t/ha for varieties CoPk 05191, Co 0118, CoH 128, CoLk 94184 and Co 05011, respectively. However the average seed cane yield for all varieties was 98.80 t/ha (Table 12.2). A total of 810.40 tonne seed cane was produced out of which 60-80% was utilized as seed material to raise seed cane crop in order to multiply the quantity of seed cane of new varieties and rest of the harvested cane was supplied by farmers to sugar mill for crushing. The average net profit recorded for seed cane crop was ₹ 2,55,581 per ha, however, it varies between ₹ 1,89,520 to ₹ 2,88,700 per ha which is much higher than the average net profit of ₹ 80,000 to 1,00,000 per ha earned by cane farmers in mill zone area.

Table 12.1: No. of plots & area under seed cane crop of each variety (2015-16)

Sugarcane variety	No. of plots	Area in ha
CoPk 05191	16	3.88
Co 0118	9	1.88
CoH 128	2	0.24
CoLk 94184	4	0.42
Co 05011	4	0.46
CoLK 9709	4	0.50
Co 0238	1	0.32
Total area	40	7.70

The entrepreneurship training for beneficiary farmers was organised in the months of September, October, December and February to provide information in seed cane crop raising, motivate the farmers for enterprising in cane seed production and multiplication of new sugarcane varieties. The data on entrepreneurial ability of farmers was collected with the help of interview schedule comprising 10

Table 12.2. Yield, seed cane production & utilization, economics of seed cane crop of each variety (2014-15)

Variety	Average yield (t/ha)	Total seed cane produced (t)	Seed cane utilization pattern		Return (₹/ha)			Net Profit (₹/ha)
			For seed multiplication	Crushing	Seed @ ₹ 350/q	Crushing @ ₹ 280-290/q	Total	
CoPk 05191	110	431.20	258.72 (60%)	172.48 (40%)	2,31,000	1,27,600	3,58,600	2,58,600
Co 0118	115	55.20	44.16 (80%)	11.04 (20%)	3,22,000	66,700	3,88,700	2,88,700
CoH 128	88	89.76	62.83 (70%)	26.93	2,15,600	73,920	2,89,520	1,89,520

parameters/traits of entrepreneur behaviour (EB) *viz.*, risk taking, innovativeness, hope of success, persuasability, manageability, self confidence, knowledgeability, persistence, use of feedback, achievement motivation.

Pre-*Kharif Kisan Sammelan* organized

Pre *Kharif Kisan Sammelan* was organized by Krishi Vigyan Kendra, ICAR-IISR, Lucknow on July 11, 2015 with the objective of creating awareness among the farmers on developed latest technologies from various research institutions/ agricultural universities and acquainting about effect of climate change on the various crops,. Technology showcasing, technical sessions, award for innovative farmers, farmers-scientist interaction, and farmers' feedback were the major component of the programme. The programme was inaugurated by Shri Kaushal Kishore, Hon'ble Member of Parliament and presided over by Dr. O.K. Sinha, Director, ICAR-IISR, Lucknow. Dr. U.S. Gautam, Zonal Project Director, Zone-IV, Kanpur; Dr. M.C. Diwaker, Director, Directorate of Sugarcane Development, Ministry of Agriculture and Farmers Welfare, Govt. of India and Dr. S. Rajan, Director, ICAR-Central Institute of Sub-tropical Horticulture, Lucknow were Special Guests of Honour. Dr. O K Sinha, Director, ICAR-IISR welcomed the dignitaries and farmers, He focussed on developed technology of sugarcane and linked farmers for its dissemination at farmers field. In his introductory remarks, Dr. R.K. Singh, Head, KVK, Lucknow highlighted the objectives of the programme and role and achievements of the KVK. Dr. M.C. Diwakar called upon the scientists to avail benefits of central scheme for sugarcane development. Dr. Shailendra Rajan, Director, ICAR- CISH, Lucknow focussed about latest developed technologies for mango, guava, *bael*, *jamun* and *aonla* and highlighted the need for the development of proper linkage between KVK and research institutions. Dr. U.S. Gautam, Zonal Project Director, Zone IV emphasized on the awareness among the farmers pertaining to innovative technologies, focussed on farmers-farmers extension tools for transfer of technology at grass root level. He stressed upon the secondary agriculture, value addition in horticultural produce, empowering the farm women in agriculture, formation of Self Help Group and linked with banking institution for providing financial supports, capacity building of rural youths for skill development in various enterprises, developing market linkages for getting remunerative prices of agricultural produce for improving livelihood of farming community. Sh. Kausal Kishore, Hon'ble M.P. gave valuable remarks on organic farming, concept of *Swadeshi* in agriculture, conservation of landraces and wild genotype, and vermi-composting, production of manure, bio-pesticide, conservation of indigenous planting materials and quality seed production. He emphasized that farmers should avoid excess use of chemical fertilizers, pesticides and use of hybrid seed for improving the productivity of farm and soil health. He mentioned that there was need to conserve the traditional knowledge and ITK (Indigenous technical knowledge), which is treasure of our agriculture. Without this, our agriculture cannot sustain and will not fulfil the requirement of future. Dr. R.K. Singh extended sincere thanks to all dignitaries, farmers, experts, and press & media personnel.

Technology and Machinery Demonstration Mela organized at ICAR-IISR, Lucknow

A Technology & Machinery Demonstration Mela was organized by ICAR-IISR Lucknow, AICRP (FIM) and AICRP (PHET) Lucknow centres at ICAR-IISR, Lucknow on March 18, 2016. A total of 650 farmers from different districts of Uttar Pradesh visited the *Mela*.

The Mela was inaugurated by the Chief Guest, Dr. S.R. Singh, Ex. Vice-Chancellor, Rajendra Agricultural University, Samastipur (Bihar). In his address, Dr. Singh stressed the urgent need of taking the developed implements and machinery to the farmers without any delay. Dr. Singh emphasized on the development of machinery for small farmers to make the

mechanization affordable to them. Dr. Singh also emphasized that mechanization is helpful in solving the problem of scarcity of labourers for agriculture, economy of seed, fertilizer and water application, better germination, and in increasing farm productivity and income. Highlighting the potential and benefits of machineries developed at IISR, Lucknow, Dr. A.D. Pathak, Chairman of the function and Director, IISR pointed out the need for Government support in terms of providing enabling policy environment for speedier dissemination of these farm machineries. He also highlighted that such mechanization events have been organized all over the country under the ambit of ICAR AICRP Schemes on the Farm Implements and Machinery as well as under AICRP on Post-harvest Technology.

The Mela event was coordinated by Dr. A.K. Singh, Head, Division of Agricultural Engineering. Speaking on the occasion, Dr. Singh stressed the need for mechanization in sugarcane keeping in view the labour scarcity in villages due to implementation of number of employment related Government schemes and informed about the success stories of farm implements and machineries developed at the Institute. Dr. S.I. Anwar, Incharge, Jaggery Unit apprised about the nutritional qualities of jaggery and its medicinal value and proposed the vote of thanks. About six hundred and fifty farmers from various districts of Uttar Pradesh participated in the *Mela*.

During the *Mela*, farm machinery developed at ICAR-IISR, Lucknow for mechanization of sugarcane agriculture and jaggery manufacturing technology including three pan jaggery furnace, moulding frame and storage bins were exhibited and explained to the farmers. Live demonstrations of machineries were also performed in front of the farmers. Main piece of attraction was field demonstration of deep furrow sugarcane planter, trench planter and sugarcane cum potato planter. The farmers took keen interest in the machinery and equipment exhibited and expressed satisfaction that their visit was very fruitful.

Jaggery making technology was also demonstrated to visiting farmers.

Transfer of three pan furnace technology for jaggery manufacturing

Krishi Vigyan Kendra, Lucknow Activities

During 2015-16, a total of nine on-farm trials (OFTs) on different thematic areas were conducted to identify the suitable technologies of various farming systems in Lucknow district. Four hundred and twenty demonstrations in 92 ha area were conducted under different crops and 1,000 animals were covered under vaccination and deworming packages. Eighty six training programmes were conducted for farmers, farm women, rural youths, and extension personnel. Apart from above a total 1720 participants (1178 male, 542 female) attended KVK programmes on different aspects of training. Moreover, this KVK also organized *Kharif Purva Kisan Sammelan*, International Soil Day and *Pradhan Mantri Fasal Bema Yojana*. The details of the achievements of KVK, Lucknow is given below:

A. On Farm Testing/Trials (OFTs): Nine OFTs were conducted pertaining to various disciplines as per identified major thrust areas. OFTs are most important mandatory component of KVK under which evaluation of recently developed technologies or varieties is carried out in specific agro-climatic condition for developing recommendations or popularization. The details are as under:

- Evaluation of organic crop production in rice
- 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 of mangoes
- Effect of perennial fodder grasses to milch animal

B. Frontline Demonstration: A total of 420 FLDs on oil seeds pulses and other crops or enterprises were conducted at farmers' field in an area of 92.0

Performance of Frontline demonstrations on Oilseeds

Crop	Technology demonstrated	Variety	No. of farmers	Area (ha)	Yield (q/ha)				% Increase in yield over check	Economics of demonstration (₹/ha)			
					Demo			Check		Cost	Gross return	Net return	BCR (B/C)
					High	Low	Average						
Sesamum	Improved variety	Shekhar	9	4	4.5	3.1	3.8	2.6	46.15	12,700	17,100	4,400	1.48
Mustard	Improved variety	Shatabdi	56	20	17.50	12.8	15.15	10.75	40.93	12,570	54,540	41,970	3.33
	Mgt. of aphid		10	2	26.75	23.80	25.5	20.70	23.20	35 850	76 500	40 650	2.10

Frontline demonstration on pulses

Crop	Technology demonstrated	Variety	No. of farmers	Area (ha)	Yield (q/ha)				% Increase in yield over check	Economics of demonstration (₹/ha)			
					Demo			Check		Cost	Gross return	Net return	BCR (B/C)
					High	Low	Average						
Pigeonpea	Improved variety	Narendra Arhar 2	12	6	21.65	18.25	20.35	16.55	23.0	20750	87505	66755	3.22
Fieldpea	Improved variety	Prakash	106	20	18.5	16.0	17.25	15.0	16.66	22000	69258	47258	2.14

** BCR= Gross return/cost

FLD on other crops

Category & Crop	Name of the technology	No. of farmers	Area (ha)	Yield (q/ha)				% Change in yield	Economics of demonstration (₹/ha)			
				Demo			Check		Cost	Gross return	Net return	BCR (B/C)
				High	Low	Average						
Paddy	IPM	13	4	78.7	71.5	75.2	58.9	27.8	37800	116532	78732	3.08
Wheat	Improved variety	24	5	41.35	37.5	39.7	36.6	8.46	33500	57565	24065	1.72
	Zero tillage	10	2	40.2	37.2	38.5	36.6	5.19	26820	55825	29005	2.10
Bottlegourd	Use of fruit fly trap	5	2	275.7	258.4	259.2	215.65	16.8	64560	259220	194660	4.01
Tomato	IPM technology	5	1	710.5	670.3	691.4	589.7	17.2	170000	691400	521400	4.06
Brinjal	IPM technology	5	1	618.7	567.7	587.6	511.3	14.9	50310	470080	419770	9.34
Cauliflower	Improved variety (Agrim Sabour)	5	1	211.8	200.5	207.85	197.86	4.8	52500	207850	155350.0	3.96
Vegetable pea	Improved variety (Kashi Uday)	29	2	76.5	61.9	69.9	52.75	31.9	51440	89350	37910	1.74
Potato	IPM technology	9	1	317.2	307.6	311.2	230.7	34.9	100900	311200	210300	3.00
Sorghum (F)	Improved variety	24	5	650.5	595.37	607.34	463.9	30.92	25470	91101	65631	2.58
Berseem (F)	Improved variety	20	5	495.5	389.7	436.5	335.6	29.5	24470	21775	2695	1.12

Frontline demonstration on livestock

Category	Name of the technology demonstrated	No.of Units (Animal/ Poultry/ Birds)	Major parameters		% change in major parameter
			Demo	Check	
Vaccination	Raksha Riobock Vaccine	1000	Vaccinated	Not vaccinated	100% HS,FMD dis. Control

C. Other Extension Activities:

Activity	No. of programmes	No. of farmers	No. of extension personnel
Advisory Services	125	-	-
Diagnostic visits	9	125	-
Field Day	4	200	-
Group discussions	11	180	20
Kisan Gosthis	8	1150	25
Film Shows	25	500	16
Kisan Mela	1	550	25
Exhibitions	3	750	30
Scientists' visit to farmers fields	105	765	-
Farmers' seminar/workshop	1	450	50
Method Demonstrations	18	360	-
Celebration of important days	02	75	-
Total	311	4925	164

D. New Initiatives:

- Established a low cost mushroom production unit at KVK to skill farmers of Lucknow district
- Evaluation of different organic products in horticultural crops
- Large scale demonstration of pulse crops in Lucknow district
- Introduction of exotic vegetables as a high value crop in Lucknow district
- Popularization of intercropping of turmeric in mango orchards
- Introduction of plastic mulch in vegetable cultivation
- Introduction of pruning and stacking in tomato cultivation
- Popularization of perennial grasses as a fodder crop
- Value addition of different horticultural crops

Initiatives with foreign cane growers and millers

Indonesian Delegation of State owned Sugar Factories visited IISR, Lucknow

2016. The delegation was accompanied by four other members to provide their logistic support. The delegation was welcomed and a brief account of IISR activities was provided in an interactive session organised on the occasion. The delegation apprised about the state of sugarcane cultivation in Indonesia and highlighted the problem of low cane yields in the country. The President, Mr. Subiyono also highlighted

that Indonesia meet most of its sugar demand from imports and is interested to raise the domestic production of sugar. The delegation highlighted that very old varieties are being grown in Indonesia and there is a need to replace these varieties. The delegation was desirous of exchange of planting material between the two countries and is earnest to have collaboration with IISR, Lucknow for bringing about higher productivity. After discussion, it was agreed that (i) there is a need for collaboration in sugarcane research with Indonesia where in high sugar breeding stocks developed at IISR could be used for strengthening breeding research in Indonesia. (ii) IISR may help Indonesia in the rejuvenation of old varieties. (iii) The Indonesian Sugar Industry is finding it difficult to attract best researchers, hence with the help of IISR; the capacity building of researchers could be carried out.

Visit of South African Cane Growers

A ten member delegation of Natal Cane Growers Association, South Africa under the Chairmanship of Mr. Yaga Govender, the President of the Association visited the ICAR- Indian Institute of Sugarcane Research, Lucknow on February 25, 2016. The delegation was interested to discuss certain issues pertaining to sugarcane cultivation in South Africa. An informal interactive session was organized

wherein the Heads of the Divisions and a few invited scientists participated in the discussion.

The President of the Association gave a brief glimpse of the sugarcane cultivation scenario and highlighted the major constraints in sugarcane cultivation in the South Africa. The delegation highlighted that sugarcane cultivation in South Africais generally rain fed and about 95% cane is burnt before harvesting. The use of ripeners is being carried out and there is problem of thrips and borers as well as smut, rust and mosaic diseases. It was also highlighted during discussion that the biocontrol of insect pests and diseases is still on experimental basis. The crop is cultivated on minimum tillage and 7 consecutive ratoons are taken. The yield levels vary from 60-70 t/ha.

13

Services to 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 by signing a MoU with the company or agency as per details given below (Table 13.1).

Table 13.1. MoUs for Contract Research- service to industry

Company/ Organization	Details of the project	Budget (₹ in lakh)	Duration	Associated researchers
CSMCRI, Bhavnagar	Response of seaweed saps and potassic fertilizer in sugarcane yield	5.00	2015-16	Ishwar Singh
CSMCRI, Bhavnagar	Performance evaluation of different potassic fertilizer in sugarcane	10.00	2016-17	Ishwar Singh
FMC India Ltd., Bangalore	Bio-efficacy testing of FMC (I) 113 against termites in sugarcane	7.50	2014-16	Arun Baitha, R.J. Lal and S.K. Shukla
United Phosphorus Ltd., Mumbai	Evaluation of efficacy of Lancergold (Acephate 50% + Imidacloprid 18%SP) against black bug, early shoot borer, white grub and termite	2.00	2014-16	Arun Baitha, R.J. Lal and S.K. Shukla
Biodeg Chemical & Allied Industry & Kemtech Polymers, New Delhi	Effect of Biodeg products on biochemical attributes, cane yield and juice quality of sugarcane	3.00	2014-16	Radha Jain, A. Chandra and S.K. Shukla
Privi Life Sciences Pvt. Ltd., Navi Mumbai	Effect of Silixol on growth, yield and juice quality attributes of sugarcane	5.00	2014-16	Radha Jain, A. Chandra and S.K. Shukla
Cytozyme Labs, Gurgaon	Effect of Cytozyme (USA) products on growth, yield and quality of sugarcane	10.00	2015-17	A.K. Shrivastava, Pushpa Singh, SP Shukla and CP Prajapati
Zuari Agro Chemicals Ltd., Goa	Evaluation of efficacy of sulphur and zinc containing complex fertilizers for enhancing yield through balance nutrition of different crops in India	15.11	2015-17	S.K. Shukla
Bayer CropScience Ltd., Mumbai	Bioefficacy evaluation of tembotrione 420 SC (laudis 420 SC) in sugarcane	8.00	2016-18	V.P. Singh, K.K. Singh, S.N. Singh and S.K. Shukla
SDS Ramcides CropScience Pvt. Ltd., Chennai	Evaluation of Atrazine 50% WP against weeds in sugarcane	3.00	2016-17	V.P. Singh, V.K. Singh, S.K. Shukla and T.K. Srivastava

Response of sugarcane to seaweed sap and potassic fertilizer

The research project on 'Response of sugarcane to seaweed sap and potassic fertilizer' was funded by CSIR- Central Salt & Marine Chemicals Research Institute, Bhavnagar (Gujarat). A field experiment, comprising twelve treatments including seaweed saps and potassic fertilizers was conducted during 2015-16 in randomized block design (RBD) with three replications. Seaweed saps, *Kappaphycus*, *Gracilaria* and GA_3-free K sap, in addition to 75% of recommended dose of fertilizers (RDF) was applied in three (60, 90 and 120 days after planting, DAP) and two (90 and 120 DAP) sprays with 5.0% sap solution and compared with 75 and 100% RDF. Two indigenous potassic fertilizers, sulphate of potash (SOP) and schoenite were compared with murate of potash (MOP). In seaweed sap treatments, cane setts were also treated with 1.0% sap solution before planting. The soil of the experimental site was sandy loam in texture, low in organic carbon (0.32%), available nitrogen (227.4 kg/ha), medium in phosphorus (26.3 kg P_2O_5/ha) and potassium (182.4 kg/ha) and slightly alkaline in reaction (pH 8.4). Sugarcane variety CoPk 05191 was planted on March 30, 2015.

The experimental findings revealed that germination in sugarcane improved with cane sett treatment with 1.0% seaweed sap solution. Sett treatment with 1.0% sap solution of GA_3-free K sap significantly enhanced germination in sugarcane. The tiller population recorded on July 13, 2015 was significantly the highest (265.4 thousand per hectare) in the treatment of GA_3-free K sap. The tiller population started declining after the month of July due to tiller mortality. Plant height, LAI and dry matter accumulation were also improved with seaweed sap application. The sugarcane plant height, recorded at harvest was the highest (240 cm) in the treatment of schoenite application. Application of seaweed sap spray improved the cane yield due to higher NMC, cane length and cane weight. Among the seaweed saps, the cane yield was significantly highest (78.89 t/ha) in the treatment of GA_3-free K sap applied at 60, 90 and 120 DAP to the tune of 17.03% over control (75% RDF) due to higher NMC and cane

Bio-efficacy evaluation of atrazine 50% WP against weeds in sugarcane

Weed problems have increased with high-input agriculture. These necessitate continuous monitoring and upscaling of weed management strategies on a long-term basis. Sugarcane being a long duration, availability of wider inter space and initial slow growing nature of cane crop encourages the weed growth, right from planting to harvesting. Weeds limit the cane and sugar yield, relative to its species and intensity. Evaluation of new herbicide molecule/new commercial product of established herbicide is a continuous process for upscaling of weed management strategies. Keeping these points in view, a field experiment on spring planted sugarcane was carried out during 2015-2016 with aim to assess the bio-efficacy of new commercial product of atrazine 50% WP alone and in combination with other herbicides/methods on growth and development of weeds in sugarcane. Eleven treatments consisted of sole application of atrazine and sulfentrazone; and in sequential application/as IWM practices including hoeing and weedy check control. The experiment was conducted in randomized Complete Block Design (RCBD) with three replications.

Predominant weed species in spring planted sugarcane were *Echinochlo acolona, Dactyloctenium egyptium,* and *Panicum repens* among grasses; and *Cyperus rotundus* among sedges. There was significant effect on weed flora distribution, total weed population and weed dry matter production due to different weed management practices. Significantly lowest *E. colona, D. aegyptium* and *P. repens* was recorded with pre-emergence application of atrazine @ 2.0 kg/ha followed by (*fb*) manual hoeing and lay by application of atrazine @1.0 kg/ha fb post-emergence (PO) application of 2,4-D @ 1.0 kg/ha; which was at par with application of either atrazine or sulfentrazone fb trash mulching @ 10.0 t/ha. Whereas, manual hoeing being at par with pre-emergence application atrazine *fb* 2,4-D as PO at 60 DOP fb manual hoeing at 90 DOP recorded the lowest population of *P. repens*. Pre-emergence application of atrazine @ 2.0 kg/ha followed by (*fb*) manual hoeing and atrazine+trash mulching *fb* 2, 4-D reduced the emergence of *C. rotundus* (Table 13.2). Different weed

3.2. Weed dynamics, millable cane and cane yield as influenced by integrated weed management in spring season

t	Dose (kg/ha)	Weed density (No./m²) at 60 DOP					Total weed dry biomass (g/m²)	Millable cane (000/ha)	Pol (%)	Cane yield (t/ha)
		Echinochloa colona	*Dactyloc tenuisp*	*Panicum repens*	*Cyperus rotundus*	Total weed density				
0% W.P. sample)	2.0	6.3	6.0	4.3	23.3	39.9	155.2	82.5	19.00	50.13
0% W.P ample)	2.0	5.3	3.3	3.7	24.7	37.0	97.8	98.4	19.14	53.50
one	0.8	6.7	7.3	11.0	24.0	49.0	184.2	120.3	18.43	52.57
n fb 2,4-D	1.0+1.0	6.0	6.7	5.0	24.7	42.4	143.8	120.9	18.63	53.26
one fb	0.8+1.0	4.7	2.0	10.3	19.7	31.7	111.0	123.7	18.26	54.03
fb hoeing razine fb	2.0+1.5+1.0	1.3	1.3	5.3	10.7	23.6	99.7	152.1	18.08	56.97
b 2,4-D fb	2.0+1.0	3.3	4.3	2.3	22.0	31.9	93.3	153.1	18.32	58.07
+ trash (10 t/ha) hoeing	2.0 fb 1.0	2.3	2.3	2.3	17.3	24.2	49.5	149.4	18.35	58.73
one + ching (10 2,4-D fb	2.0 fb 1.0	2.3	1.7	3.0	20.0	27.0	74.1	150.1	17.86	57.47
ing (3)	-	4.7	2.0	1.3	20.0	28.0	35.9	153.9	18.63	59.63
Check	-	15.0	18.3	15.7	42.7	91.7	301.9	56.4	17.72	35.07
05)		2.7	3.6	3.6	11.9	12.0	40.3	19.8	0.96	7.93

sugarcane affected the yield significantly and yield attributing characters of sugarcane. Significantly highest millable cane (1,53,900/ha) and cane yield (59.63 t/ha) was recorded with manual hoeing thrice at 30, 60 and 90 DOP, but it was at par with pre-emergence application of either atrazine or sulfentrazone +trash mulching *fb* post-emergence application of 2,4-D. The lowest millable cane (56,400/ha) and cane yield (35.07 t/ha), which was significantly inferior to rest of the treatments. Growing weeds throughout crop season caused 63% and 41% reduction in millable cane and cane yield, respectively. The different weed management practices effect on juice quality (Pol%) was not significantly observed during period of the study. This may be due to the fact that juice quality is the inherent ability of genotype. However, the unweeded check has registered the lowest Pol per cent.

Evaluation of F 8072 and F 9253 herbicides for weed control in sugarcane

The study was conducted during spring season of 2015-16 to assess the effect of herbicides mixtures and weed control treatments under three set of experiments. The treatments of Exp 1 were T_1- Untreated Control; T_2- F 8072 @ 560+600 g a. i. /ha; T_3- F 8072 @ 700+750 g a.i./ha ; T_4- F 8072 @ 840+900 g a.i./ha ; T_5- F 6285 @ 700 g a.i./ha ; T_6- F 6285 @ 720 g a.i./ha; T_7- F 57020 @ 750 g a.i./ha; T_8- F 57020 @ 1000 g a.i./ha; T_9- Atrazine 50% WP @ 2000 g a.i./ha; T_{10}- Metribuzin 70% WP @ 1500 g a.i./ha and T_{11}- Hand weeding thrice at 30, 60, 90 DAP. The experiment No 2 comprised of T_1- Untreated Control; T_2- F 9253 @ 450.4+420 g a.i./ha; T_3- F 9253 @ 563+525 g a.i./ha ; T_4- F 9253 @ 675.6+630 g a.i./ha ; T_5- F 57020 @ 563 g a.i./ha; T_6- F 57020 @ 1000 g a.i./ha; T_7- Metribuzin 70% WP @ 525 g a.i./ha; T_8- Metribuzin 70% WP @ 1500 g a. i./ha ; T_9- Atrazine 50% WP @ 2000 g a.i./ha; T_{10}- Atrazine 50% WP + 2,4 D @ 2000 + 2000 g a.i./ha and T_{11}- Hand weeding thrice at 30, 60, 90 DAP. The effect of different pre-mix herbicide were studied on growth of prevalent weeds in sugarcane, phyto-toxicity to sugarcane, growth attributes of sugarcane, cane yield and quality traits of the crop. The field experiment was laid in Randomized Complete Block Design (RCBD) with three replications. Under third 8072 @ 840+900 g a.i./ha and found similar to F 8072 @ 700+750 g a.i./ha and hand weeding thrice at 30, 60, 90 DAP at all the growth stages. However, the dry matter accumulation by weeds was the lowest with three-hoeing as observed at the same growth stages. All the weed control methods were found significantly effective in increasing the cane yield. Three-hoeings treatment achieved the highest cane yield (87.6 t/ha) followed by application of F 8072 @ 840+900 g a.i./ha and F 8072 @ 700+750 g a.i./ha. The quality parameters *viz.*, brix, pol and purity were not affected by different treatments.

From another set of trial, it was observed that weed growth in terms of weed density recorded to be the lowest under the application of F 9253 @ 675.6+630 g a.i./ha and found similar to F 9253 @ 563+525 g a.i./ha and hand weeding thrice at 30, 60, 90 DAP at all the growth stages. However, the dry matter accumulation by weeds was the lowest with three-hoeings as observed at the same growth stages. Three-hoeing treatment achieved the highest cane yield (85.4 t/ha) followed by application of F 9253 @ 675.6+630 g a.i./ha and F 9253 @ 563+525 g a.i./ha. The quality parameters *viz.*, brix, pol and purity were not affected by different treatments.

The experiment on phyto-toxicity revealed that pre-em application of pre-mix herbicide even at higher rates significantly reduced the weed dry matter accumulation and weed density at the 60, 90 and 120 DAP without any phyto-toxicity to sugarcane. There was increase in number of millable canes by both pre mix herbicides *viz.*, F 8072 and F 9253. The increase in number of millable canes led to increase in cane and sugar yields.

Assessing bio-efficacy of Imidacloprid 40% + Fipronil 40% - 80 WG against white grub, termite and shoot borer and its impact on cane yield and sugar recovery

The experiment was conducted with seven treatments comprising different doses of Imidacloprid 40% + Fipronil 40% and other sources of insecticides against insect pests (white grub, termite, shoot borer) in sugarcane and also to assess the impact of above insecticides on growth, cane yield and sugar recovery in sugarcane in subtropical India. The field

at 75 cm apart in the experiment. Initial soil health parameters indicated that at 0-15 cm and 15-30 cm soil layers for organic carbon, pH, EC and Available N, P and K were 0.47% and 0.26%, 8.20 and 8.17, 0.17 ds/m and 0.15 ds/m, 237 kg/ha and 187.13 kg/ha, 30.13 kg/ha and 19.70 kg/ha and 280.34 kg/ha and 247248.63 kg/ha, respectively.

Experimental data clearly indicated that the germination per cent of cane buds did not differ significantly due to different treatments in the test, and were more or less similar. The number of shoots counted at 60, 90 and 120 days after planting were significantly higher under T4 treatment as compared to other treatments in the test, but it was statistically at par with the T2, T3 and T7 treatments. The number of millable canes counted at the time of sugarcane harvesting showed almost the similar trends as the number of shoots counted at different stages of crop growth. The cane yield obtained under the treatments of T2, T3, T4 and T7 being statistically at par among themselves produced significantly higher values than that of other treatments. The above treatments, cumulatively, produced the higher cane yield to the tune of 12.74%, 7.37% and 6.03% as compared to T1, T5 and T6 treatments, respectively. The data recorded on cane length, cane diameter and per cane weight exhibited almost the same trend as the yield of cane in different treatments in the test. Cane quality parameters *viz.*, °Brix, Sucrose %, Purity Coefficient % and CCS % did not differ significantly due to different treatments in the test. Therefore, the above results clearly nullify the misconception that the application of Imidacloprid 40% + Fipronil 40% - 80 WG (as per the doses we tried) at the time of planting declines the quality of cane. Imidacloprid 40% + Fipronil 40% -80 WG @ 400 g a. i./ha has been found significantly superior over all the treatments with the lowest sett damage (21.80%). Observations on incidence of root borer were recorded by digging the clumps from two meter row length at two places in each replicated plot in the month of July. Imidacloprid 40% + Fipronil 40% -80 WG @ 400 g a. i./ha and fertera @ 75 g a. i./ha were significantly superior over untreated control and other treatments with the incidence of 19.07 per cent and 19.63 per cent, respectively. Early shoot borer and white grub are not the pests of sugarcane at ICAR-IISR, Research Farm.

Effect of Cytozyme (USA) Products Seed + Extra, Soil+, CytoNutri Zinc, CytoNutriBoron and CytoNutriPotassium and CROP XL on Growth, Yield and Quality of Sugarcane in Subtropical India

A study was conducted to observe the effect of Cytozyme, an algal formulation, on sugarcane crop production and productivity. The treatments were T1: Foliar applications of Crop XL at 1,000 ml/ha with CytoNutri Zinc at 750 ml/ha at 50-55 cm height during tillering followed by similar application two weeks after the first spray; T2: At planting: Seed+Extra at 500 ml/ha with Soil+ at 500 ml/ha sprayed directly onto the sugarcane seed pieces planted in furrows + Foliar applications as in T1). It was observed that there was no significant difference in germination and T_{max}, NMC and cane yield in response to treatments in comparison to control in both autumn as well as spring planted crops. Juice analysis revealed that before harvest, in latter one °Brix was not significant, however, in former one, the difference was significant. Pol% Juice was not significantly different in both autumn and spring planted crops, however, purity coefficient was significantly higher in former than the latter, however, it was not significant as compared to respective controls. Reducing sugars was not significantly different in both the crops. It was also observed that average cane weight was significantly higher in the spring planted crop while it was not so in the autumn planted crop. On an overall basis, there is no significant effect of the Cytozyme formulations on sugarcane crop with respect to its growth characteristics as well as juice quality.

14

Trainings and capacity building

Model Training Course organized

Model Training Course on Advances in Sugarcane Agri-business Management Systems was organized at ICAR-IISR, Lucknow from October 6-13, 2015. The training course was inaugurated by the Managing Director, UP Cooperative Sugar Federation, Lucknow on October 6, 2015. The Valedictory function was organized on October 13, 2015 in which Shri Virender Singh, Additional Commissioner, Directorate of Extension, Ministry of Agriculture and Farmers Welfare, Govt. of India was The Guest of Honour.

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, 2015. A total of 16 cane managers/officers from Uttar Pradesh, Bihar and Haryana participated in this training. In an ice-breaking session organized at the beginning, the training need of participants and their expectations from this training were assessed and training module was reoriented and implemented in true-spirit of participants' expectation. 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 ICAR-IISR technologies and to spread the technologies with expected dividends of high sugarcane and sugar productivity.

In addition to above training, District cane Officers, NGO personnel and farmers were trained in latest cane cultivation technologies under different training programme organized, as given in Table 14.1.

Table 14.1. Short duration training programmes organized

Name of training	Topic	Duration	Sponsoring agency	No. of participants
For students				
8 days student training	Advances in Sugarcane Production Technology	May 26-June 02, 2015	BHU, Varanasi	20

Name of training	Topic	Duration	Sponsoring agency	No. of participants
For master trainers				
2 days National Training	Improved cane varieties and planting methods for higher yield of sugarcane	February 10-11, 2016	DAC, Ministry of Agriculture and Farmers' Welfare, Govt. of India	20
2 days National Training	Integrated nutrient and weed management in Sugarcane	February 15-16, 2016	DAC, Ministry of Agriculture and Farmers' Welfare, Govt. of India	20
2 days National Training	Intercropping options in sugarcane for enhancing system productivity and profitability	February 23-24, 2016	DAC, Ministry of Agriculture and Farmers' Welfare, Govt. of India	20
2 days National Training	Integrated pests and diseases management in sugarcane	February 25-26, 2016	DAC, Ministry of Agriculture and Farmers' Welfare, Govt. of India	20
2 days National Training	Mechanisation and post harvest management in sugarcane	March 27-28, 2016	DAC, Ministry of Agriculture and Farmers' Welfare, Govt. of India	20
For farmers				
2 Days Farmers' Training	*Ganna Utpadan Taknik*	June 09-10, 2015	RACHNA, an NGO, Deoghar, Jharkhand	21
One day Training	Entrepreneurship in Sugarcane	October 28, 2015	IGICM, Lucknow	20
One Day Training	*Ganna Utpadan Taknik*	December 27, 2015	IISR RC, Motipur (Bihar)	100
3 Days Farmers' Training	Sugarcane Production Technology	February 8-10, 2016	Director of Agriculture, Nilakottai, Dindigul District, Tamil Nadu	16
3 Days Farmers' Training	Sugarcane Production Technology	February 1-3, 2016	ATMA, Seoni, M.P.	14
5 Days Farmers' Training	गन्ना उत्पादन की उन्नत कृषि तकनीक	February 16-20, 2016	ATMA, Motihari, East Champaran, Bihar	30
3 Days Farmers' Training	Sugarcane Production Technology	March 10-12, 2016	Assistant Director of Agriculture, Paramkudi, Ramanathapuram	20

One day training-cum-visits organised

The Institute provided exposure to the sugarcane improved technologies and quality jaggery making to around 1,169 farmers, students and other clients/state holders as per details given below:

Farmers	554
Farmer entrepreneurs	206
Development personnel	164
Students	240
Teachers/Scientists	5
Total	1169

Other capacity building programmes

1. One ARS trainee (Dr. Priyanka Chandra) Microbiology is undergoing subject matter attachment training under Dr. Amaresh Chandra since March 2016.
2. Six Ph.D students (One CSIR and one UGC fellowships holders), enrolled to different Universities and working in the Institute for their Ph.D.
3. One women scientist (WOS-A) Scientist working under Dr Amaresh Chandra since 2015.
4. ITI Apprenticeship trainings are organized in Division of Agricultural Engineering every year.
5. Number of UG/PG students and project trainees are working under different scientists.

KVK training programmes

Krishi Vigyan Kendra at Lucknow offered 86 training courses for participating farmers, farm women on various topics with an objective to improve skill and upgrade the knowledge of farmers about developed and potent products/technologies. All training programmes were skill oriented and conducted the principles of "Learning by doing". A total of 1720 participants (1178 males, 542 females) attended the programme as per details given below:

KVK training programmes

Clientele group	No. of Courses	Male	Female	Total participants
Farmers & farm women	74	1033	447	1480
Rural youths	8	85	75	160
Extension functionaries	4	60	20	80
Total	**86**	**1178**	**542**	**1720**

Training attended by IISR Scientists/Staff

Name	Conference/Seminar/Symposia	Venue	Date
Dr. P.K. Singh and Dr. Sanjeev Kumar	DST Sponsored 12 days Management Programme on 'Managing Innovation and Technology for Competitiveness'	Administrative Staff College of India, Hyderabad	Jan. 04-15, 2016
Dr. Sangeeta Srivastava and Dr. Sanjeev Kumar	Subject Matter Training Course Fish genomic and proteomic data analysis with high throughput computing	ICAR-NBFGR, Lucknow	Nov. 19-24, 2015
Dr. Sangeeta Srivastava	Competency Development of Human Resource Development Nodal Officers of ICAR	ICAR-NAARM, Hyderabad	Feb. 10-12, 2016
Dr. Sangeeta Srivastava	Management Development Programme (MDP) on Leadership Development	ICAR-NAARM, Hyderabad	Nov. 30- Dec. 11, 2015
Dr. Sangeeta Srivastava	Next Generation Sequencing Workshop	CSIR-CDRI, Lucknow	Jan. 27-30, 2016
Dr. Sanjeev Kumar	Management Development Programme on Leadership Development (a pre-RMP Program)'	ICAR-NAARM, Hyderabad	Nov. 30-Dec. 11, 2015
Dr. Swapna M.	DST sponsored training on "General Management Programme for Women Scientists"	Administrative Staff College of India	Jan. 25- Feb. 5, 2016

Name	Conference/Seminar/Symposia	Venue	Date
Dr. Dilip Kumar	Training programme on Start-ups and innovation for Agri-Entrepreneurship	ICAR-NBPGR, Lucknow	30th Mar., 2016
Dr. T.K. Srivastava	Programme on Science Administration and Research Management	ASCI, Hyderabad	Aug. 17-28, 2015
Dr. Rajesh Kumar	Training Programme on Analysis of Experimental Data	ICAR-NAARM, Hyderabad	Aug. 17-22, 2015
Mr. Brahm Prakash, Mr. Adil Zubair, Mr. Yogesh Mohan Singh, Mr. S.K. Kushwaha	Training Programme for Competence Enhancement Programme for Technical Officers of ICAR (T-5 and above)	ICAR-NAARM, Hyderabad	Aug. 18-29, 2015
Dr. Om Prakash	ICAR Short training Course entitled "Advances in Micro Irrigation and Fertigation Technologies for Improving Water and Nutrient Use Efficiency"	College of Agriculture, CSK Himachal Pradesh Krishi Vishvavidayalaya, Palampur (Himachal Pradesh)	Oct. 01-10, 2015
Mrs. Meena Nigam, Sh. S.N. Srivastava, Sh. Ram Murti, Dr. Ram Kishor	Training Programme for Competence Enhancement Programme for Technical Officers of ICAR (T-5 and above)	ICAR-NAARM, Hyderabad	Oct. 6-15, 2015
Dr. Rakesh Kumar	Zonal Workshop cum Training Programme	ICAR-ATARI Zone IV, Kanpur	Nov. 18-19, 2015
Drs. Ram Kewal Singh, S.K. Shukla, Sangeeta Srivastava, S.N. Singh	Management Development Programme on Leadership Development (A Pre-RMP Programme)	ICAR-NAARM, Hyderabad	Nov. 30-Dec. 11, 2015
Sh. Chaman Singh and Sh. Surendra Nath	Training Programme (CAD/CAM) in manufacturing of Agricultural Equipment	ICAR-CIAE, Bhopal	Dec. 10-24, 2015

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Awards and Recognitions

- Drs. Amaresh Chandra, Radha Jain and Sushil Solomon were conferred with Prestigious ICAR-Hari Om Ashram Trust Award 2015.

- Dr. A.D. Pathak, Director was awarded *Dr. Punjab Singh Visishth Krishi Vaigyanik Samman* for research management by UP Government.
- Institute's Rajbhasha Patrika "Ikshu" bagged *Rajbhasha Kirti Puraskar* (First Prize) for the year 2014-15 in the "Ka" region. Dr. O.K. Sinha, Director received the award of Ministry of Home Affairs, Govt. of India by Hon'ble President of India in the ceremony held on September 14, 2015 at Vigyan Bhawan, New Delhi.

- Dr. AK Sah, Principal Scientist received *Uttar Pradesh Academy Award for Visihta Krishi Vaigyanik Purasakar-2014* from Uttar Pradesh Academy of Agril. Sciences during 3rd UP Agril. Science Congress held at SHIATS, Allahabad from June 14-16, 2015.
- Dr. S.N. Singh, Principal Scientist (Agronomy) & I/c, KVK of IISR, Lucknow was awarded *Dr. O.P. Gautam Vishisht Krishi Vaigyanik* Award of U.P. Govt. at CS Azad University of Agriculture and Technology, Kanpur on March 04, 2016.

- Dr Ishwar Singh, Principal Scientist was conferred 'Outstanding Scientist Award 2015' and the 'Young Scientist Award 2015' during 2nd International Conference on Agriculture, Horticulture and Plant Sciences held at Shimla from December 26-27, 2015.
- Dr. S.K. Shukla, Principal Scientist & Head, Division of Crop Production received SAP Gold Medal 2015 for outstanding work in Agronomy in field of Natural Resource Management by the Society of Agricultural Professionals, CSAUA&T, Kanpur.
- Dr S.I. Anwar, Principal Scientist & I/C Jaggery Unit received Commendation Medal of Indian Society of Agricultural Engineers (ISAE) during

ISAE Convention held at Bhubaneswar (Odisha) on February 19-21, 2016.

- Dr. Amaresh Chandra, Head, Division of Plant Physiology and Biochemistry was honoured Fellow of UPAAS (Uttar Pradesh Academy of Agricultural Sciences) in the category of Crop Sciences in 2015.
- Dr. A.K. Singh, Head, Division of Agricultural Engineering was honoured Fellow of UPAAS (Uttar Pradesh Academy of Agricultural Sciences) in the category of Agricultural Engineering & Technology-2015.
- Dr. Sangeeta Srivastava, Principal Scientist, Division of Crop Improvement was honoured as Fellow-2015, Uttar Pradesh Academy of Agricultural Sciences (UPAAS), Lucknow for outstanding work in the field of Crop Science.
- Dr. Sangeeta Srivastava, Principal Scientist was selected as Member of National Academy of Sciences, Allahabad (MNASc) in May, 2015.
- Dr. AK Sah, Principal Scientist received Fellow in Social Sciences of Uttar Pradesh Academy of Agricultural Sciences (UPAAS) in 2015.
- Dr. S.N. Singh, Principal Scientist, Division of Crop Production & I/c, KVK of IISR, Lucknow was conferred SAP Fellowship Award at IGFRI, Jhansi on February 20, 2016.
- Dr. S.N. Singh, Principal Scientist, Division of Crop Production & I/c, KVK of IISR, Lucknow was conferred Best Paper Presentation Award at IGFRI, Jhansi on February 21, 2016.
- Dr. AK Sah, Principal Scientist received Excellence in Research Award 2016 in a seminar organized by a NGO Samagra Vikas Welfare Society & Amulya Sanchay Producer Company Limited on January 10, 2016.
- Dr. Deepak Rai and Dr. Rakesh Kumar Singh received "Best KVK Scientist Award-2015" of Indian Society of Extension Education, IARI, New Delhi.
- Dr. Ishwar Singh, Principal Scientist was awarded with 'Best Paper Presentation Award' for his research paper presentation on 'FIRB Method: An innovative approach for enhancing productivity of wheat – sugarcane cropping system' in 2nd International Conference on Agriculture, Horticulture and Plant Sciences held at Shimla (HP), India on December 26-27, 2015.
- Dr. A.K. Singh and Er. Sukhbir Singh received Best Poster Award (First Prize) for the paper on "Mechanization of sugarcane cultivation : IISR efforts" presented during 4th UP Agricultural Science Congress held at CSAUA&T, Kanpur on March 2-4, 2016.
- Er. Sukhbir Singh and Dr. A.K. Singh received First Prize for Oral Paper presentation entitled 'Cost effective and drudgery reducing technologies for sugarcane cultivation in India: a review' in International Seminar on Indigenous Technologies for Sustainable Agriculture and Better Tomorrow held at CSIR-N.B.R.I., Lucknow on January 09-10, 2016.
- Dr. AK Sah and Dr. S.S. Hasan received Best Paper Presentation Award for paper presented on Knowledge Convergence in Extension for Skill Based Agricultural Development presented in ISEE Golden Jubilee National Seminar-2015 on "Strategy to Drive Skill Based Agriculture Development for Sustainability and Rural Employability" held at Institute of Agricultural Sciences, BHU, Varanasi (UP) on November 5-7, 2015.
- Dr. A.K. Sharma and Mr. Brahm Prakash received Best Paper Presentation Award for their paper entitled "Role of sugarcane cultivation in agricultural development of Uttar Pradesh" at Third Uttar Pradesh Agricultural Science Congress on Strategic Governance and Technological Advancement for Sustainable Agriculture held at SHIATS, Allahabad on June 14-16, 2015.
- Mr. Brahm Prakash, Dr. A.K. Sharma and Mr. A.K. Sachan received Best Paper Award for their paper entitled "Prospects of jaggery exports from India" presented at the 4th Uttar Pradesh Agricultural Science Congress held at Chandra Shekhar University of Agriculture & Technology, Kanpur during March 2-4, 2016.
- Mr. Mohd. Ashfaque, Mr. Brahm Prakash, Mr. A.K. Sachan and Dr. A.K.Sharma received Best Paper Award for their paper entitled " Problems and prospects of commercialization of technologies under National Agricultural Research System in India" presented at Fourth National Symposium on Transforming Indian Agriculture towards Food and Nutritional Security held at ICAR-Indian Grassland and Fodder Research Institute, Jhansi on February 20-21, 2016.
- Drs. Deepak Rai, Viveka Nand Singh and Veenika Singh, received Best Paper Presentation Award for

their paper entitled "Validation of management practices against mango leaf webber, *Orthega euradalis*, Walker in central plain of Uttar Pradesh" in Fourth National Symposium on Transforming Indian Agriculture towards Food and Nutritional Security organized by Society of Agricultural Professionals, CSAUA&T, Kanpur at ICAR-IGFRI, Jhansi on February 20-21, 2016.

- Dr. Sangeeta Srivastava, Principal Scientist served as Editor of three journals - Sugar Tech, Journal of Environmental Biology, and *Indian Journal of Fundamental and Applied Life Sciences*.
- Dr. Amaresh Chandra, Head, Division of Plant Physiology & Biochemistry acted as Associate Editor of an international journal Acta Phygiologiae Plantarum.
- Dr. Swapna M., Principal Scientist served as Editorial Manager of Sugar Tech Journal and Reviewer of the journals Sugar Tech and Physiology & Molecular Biology of Plants.
- Dr. Sanjeev Kumar, Senior Scientist served as a Reviewer of international journals "Scientia Horticulturae" and "Physiology Molecular Biology of Plants".
- Dr S.I. Anwar, Principal Scientist acted as Reviewer for Sugar Tech, Solar Energy and Agricultural Engineering Today
- Dr S.I. Anwar, Principal Scientist acted as Member, Project Monitoring Committee of Ministry of Environment, Forest and Climate change, Govt. of India
- Dr. PK Singh, Principal Scientist served as Secretary, Nagar Rajbhasha Karyanvayan Samiti (Karyalay-3), Lucknow by Department of Official Languages, Ministry of Home Affairs, Government of India.
- Dr. Sangeeta Srivastava, Principal Scientist acted as reviewer for Journal of Genetics (Indian Academy of Science), Plant Growth Regulation, SugarTech, Journal of Environmental Biology and World Journal of Agricultural Sciences.
- Dr. A.K. Singh, Head, Division of Agricultural Engineering was nominated as Member, Board of Studies of Agricultural Engineering of Dr. A.P.J. Abdul Kalam Technical University (formerly UPTU), Lucknow on January 12, 2016 for a period of three years.

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Publications

I. Institute publications

(a) International journals :

1. Published papers

Banerjee N, Siraree A, Yadav S, Kumar S, Singh J, Kumar S, Pandey DK and Singh RK. 2015. Marker-trait associations for sucrose and yield contributing traits in sugarcane (*Saccharum* spp. hybrid). *Euphytica* 205:185-201.

Banerji R, Solomon S, Kumar R, Ram Kishor, Singh P and Chandra A. 2015. Inhibitory effect of pre-harvest foliar application of zinc sulphate on sucrose inversion in the harvested sugarcane. *Sugar Tech* 17:322-324.

Chandra A, Keizerweerd AT, Que Y and Grisham MP. 2015. Loop-mediated isothermal amplification (LAMP) based detection of *Colletotrichum falcatum* causing red rot in sugarcane. *Molecular Biology Reports* 42:1309-1316.

Chandra A, Verma PK, Islam MN, Grisham MP, Jain R, Sharma A, Roopendra K, Singh K, Singh P, Verma I and Solomon S. 2015. Expression analysis of genes associated with sucrose accumulation in sugarcane (*Saccharum* spp. hybrids) varieties differing in content and time of peak sucrose storage. *Plant Biology* 17:608-617.

Gupta Rajendra and Khan MZ. 2015. Effect of distillery effluent (spent wash) application on aggregate size distribution and stability in sodic soils. *Sugar Tech* 17(4):367-378.

Jain R, Chandra A, Visha, KV and Solomon S. 2015. Physiological changes and expression of SOD and P5CS genes in response to water deficit in sugarcane. *Sugar Tech* 7:276-282.

Keizerweerd AT, Chandra A, and Grisham MP. 2015. analysis, fitcon analysis, EM-AMMI and proposed improved-IMAMMI under incomplete genotype and environment interaction data of sugarcane. *International Journal of Agricultural Statistics and Science* 12(1):210-216.

Shrivastava AK, Solomon S, Rai, RK, Jain R, Singh P, Shukla SP and Chandra A. 2015. Enhancing sugarcane and sugar productivity: Physiological constraints and interventions. *Sugar Tech* 17(3): 215-226.

Shukla SK, Singh PN, Chauhan RS and Solomon S. 2015. Soil physical, chemical and biological changes and long term sustainability in subtropical India through Integration of organic and inorganic nutrient sources in sugarcane. *Sugar Tech* 17(2):138–149.

Singh D, Tripathi A, Sinha AK and Tiwari TN. 2015. Studies on variability of pathogens causing black point in wheat. *International Journal of Basic and Applied Agricultural Research* 13:368-375.

Singh S, Singh PR, Singh AK and Gupta R. 2016. Present status and future need of mechanizing sugarcane cultivation in India. *Agricultural Mechanization in Asia, Africa, and Latin America* 47(1):75-81.

Singh SR, Kundu DK, Tripathi MK, Dey P, Saha AR, Kumar M, Singh I and Mahapatra BS. 2015. Impact of balanced fertilization on nutrient acquisition, fibre yield of jute and soil quality in New Gangetic alluvial soils of India. *Applied Soil Ecology* 92:24-34.

Singh S and Vatsa DK. 2015. Need of ergonomically mechanized interventions in selected farm operations in hills of Himachal Pradesh. *Agricultural Mechanization in Asia, Africa and Latin*

India. *Agricultural Engineering International: CIGR Journal* 17(4):109-114.

Singh S, Sahoo DC, Singh NK and Bisht JK. 2015. Operator physiological response and bullock draughtability during primary tillage. *Agricultural Engineering International: CIGR Journal* 17(4):115-120.

Srivastava S, Zheng Y, Kudapa H, Jagadeeswaran G, Hivrale V, Varshneya R, Sunkar R. 2015.. High throughput sequencing of small RNA component of leaves and inflorescence revealed conserved and novel miRNAs as well as phasiRNA loci in chickpea. *Plant Science* 235:46-57.

2. On line published

Chandra A, Keizerweerd AT and Grisham MP. 2016. Detection of the sugarcane disease orange rust caused by *Puccinia kuehnii* with a loop-mediated isothermal amplification (LAMP) based assay. *Molecular Biotechnology*, DOI 10.1007/s12033-016-9914-5.

Choudhary RL, Wakchaure GC, Minhas PS and Singh AK. 2016. Response of ratoon sugarcane to stubble shaving, off-barring, root pruning and band placement of basal fertilizers with a multipurpose drill machine. *Sugar Tech* DOI: 10.1007/s12355-016-0438-x.

Jain R, Singh SP, Singh A, Singh S, Chandra A and Solomon S. 2015. Response of foliar application of nitrogen compounds on sugarcane grown under water logging stress. *Sugar Tech* DOI 10.1007/s12355-015-0406-x.

Jain R, Verma RS, Singh A, Chandra A and Solomon S. 2015. Differential expression of metallothionein gene and physiological characteristics of sugarcane influenced by selenium. *Plant Growth Regulation* DOI 10.1007/s10725-015-0042-1.

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*. DOL10.10007/s12355-015-0421-y.

Kumar D and Singh Priyanka. 2016. Effect of some Indian herbs and chemicals on shelf life of sugarcane juice. *The Asian journal of Horticulture* (paper accepted for publication)

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Publications (2015-16)	Nos
Research papers in Journals	
Having "No" NAAS 2015 rating	4
Having less than 6 rating	25
Having > 6 rating	29
Total	58
Papers presented in Seminars	61
Popular articles	37
Books	3
Annual Reports	2
Newsletters	2
Extension Brochures/Tech. Folders	13
Book Chapters	10

Sources: PME Cell, ICAR-IISR, Lucknow

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Technical Programme 2015-16

Project Code No.	Title of the Project
Division of Crop Improvement	
B1.7	Collection, maintenance, evaluation and documentation of sugarcane germplasm under sub-tropical conditions (P.K. Singh, Sanjeev Kumar and J. Singh; Duration : 01/95 to LT)
B2.3	Development of sugarcane breeding stocks for high sugar (Raman Kapur and S.K. Duttamajumder; Duration : 11/93-3/16)
B2.9	Development of top borer tolerant genetic stocks of sugarcane (A.D. Pathak, R.K. Rai, Sangeeta Srivastava, M.R. Singh and Rajesh Kumar; Duration : 3/2000-03/18)
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; Duration : 10/2003-LT)
B2.14	Development of breeding stocks of sugarcane for durable resistance to red rot (D.K. Pandey, Deeksha Joshi, J. Singh and Sanjeev Kumar; Duration : 10/04 - 03/17)
B2.15	Developing sugarbeet varieties for Indian agro-climates (A.D. Pathak, Raman Kapur, S.K. Duttamajumder, Arun Baitha and A.K. Mall; Duration : 09.08-LT)
B3.17	Elucidation of species chromosomal complement in sugarcane genotypes under sub-tropical conditions (Sangeeta Srivastava and A.D. Pathak; Duration: 06/10- 05/18)
B3.18	Identification and expression analysis of resistance gene analogues against red rot disease in sugarcane (Sangeeta Srivastava, Ramji Lal and R.K. Singh; Duration : 01/10– 03/18)
B3.19	Mapping of loci linked to sugar content in sugarcane (M. Swapna, D.K. Pandey and A.K. Mall; Duration : 12/09–03/20)
B3.20	Identification and validation of molecular markers for red rot resistance in sugarcane (R.K. Singh, D.K. Pandey and Deeksha Joshi; Duration: 04/13-04/18)
B3.21	Production of disease free and genetically pure seed cane through tissue culture techniques (R.K. Singh, Sanjeev Kumar, J. Singh and S.K. Holkar; Duration : 2011-LT)
B3.22	Development of *in vitro* conservation protocol using slow-growth tissue culture techniques in sugarcane (Sanjeev Kumar, R.K. Singh (Biotech.) and J. Singh; Duration : 03/15 – 03/18)
New	Profiling and prediction of small RNA transcriptomes in sugarcane inoculated with red rot pathogen (Sangeeta Srivastava, A.D. Pathak and Dinesh Singh; Duration : 04/ 15 – 03/020)
Bm 2.1	Development of waterlogging tolerant and red-rot resistant sugarcane clones for North Central Zone (Sanjeev Kumar and Ramji Lal; Duration 2012-2015)
AICRP on Sugarcane Trials	
B1.1	Evaluation of early maturing sugarcane clones of North West Zone (J. Singh and D.K. Pandey; Duration : 02/09 to LT)
B1.2	Evaluation of mid-late sugarcane clones of North West Zone (J. Singh and D.K. Pandey; Duration : 02/09 to LT)
B1(M)	Evaluation of sugarcane clones under Zonal Varietal Trials for North Central and Eastern Zone (A.D. Pathak; Duration : 02/09 to LT)

Project Code No.	Title of the Project
Externally funded	
DBT	RNA seq for RNA seq SNP mining and linkage mapping in sugarcane (Nandita Banerji, Sanjeev Kumar and R.K. Singh; Duration: 09/14-09/17, Budget ₹ 45.85 lakh)
DBT	National certification system for tissue culture raised plants (Coordinator: R.K. Singh, PIs: Sanjeev Kumar and S.K. Holkar, Duration : 03/15-03/18, Budget ₹ 65 lakh)
PPV&	Central Sector Scheme for PPV&FRA (J. Singh and P.K. Singh; Duration : 2006 – LT)
FRA	Breeder Seed Production in Bihar (A.D. Pathak and A.K. Mall)
ICAR Network project	
NPTC-3087	Network project on Transgenics in crops (NPTC) Sub (R.K. Singh and Sanjeev Kumar, Crop : Sugarcane; Budget; ₹ 98.49 lakh; Duration : 2015-17)
seed project	Seed production in agricultural crops (Sanjeev Kumar and P.K. Singh; Duration : 2012-17)
Division of Crop Production	
New	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; Duration : 04/15 – 3/20)
A 2.36	Assessing nutrient interactions for sustaining sugarcane productivity and soil health (R.R. Verma, Ishwar Singh and R.K. Rai; Duration : 02/13-03/16)
A 1.2.30	Rationalizing irrigation water use in sugarcane through optimizing field application parameters (A.K. Singh, Rajendra Gupta and Pushpa Singh; Duration : 11/12- 10/15)
New	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; Duration : 03/15-03/18)
New	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; Duration : 03/15-03/18)
New	Developing sugarcane based integrated farming system model for small farmer holders for sub-tropical India (A.K. Singh (Agron.), T.K. Srivastava, R.K. Singh (KVK), A.K. Sharma, A.K. Singh (Pl. Path.), A.K. Singh (Ag. Engg.) and M.M. Roy; Duration : 09/15-09/18)
New	Validation of cane node technology under farmers' fields condition (S.N. Singh, A.K. Sah and C.Gupta; Duration : 02/16-02/19)
A 1.2.29	Tillage techniques in plant-ratoon system for improving soil health and increasing sugarcane yield in sub-tropical Indian (S.K. Shukla, Akhilesh K. Singh and Rajendra Gupta; Duration : 03/12-03/16)
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; Duration : 1/12-12/15)
Externally funded project	
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 (S) Trials	
AS 42	Agronomic evaluation of promising genotypes of sugarcane (S.R. Singh and S.K. Shukla; Duration : LT)
AS 63	Response of sugarcane crop to different plant nutrients in varied agro-ecological situations (C. Gupta, S.N. Singh, S.K. Shukla and A.K. Singh; Duration : 2011-2015)

Project Code No.	Title of the Project
AS 64	Enhancing sugarcane productivity and profitability under wheat-sugarcane cropping system (Ishwar Singh and S.N. Singh; Duration: 10/12-06/15)
AS 65	Priming of cane node for accelerating germination (S.N. Singh and T.K. Srivastava; Duration : 2012-2015)
AS 66	Optimization fertigation schedule for sugarcane through micro-irrigation technique under different agro-climatic conditions (Rajendra Gupta, S.K. Shukla and C. Gupta; Duration : 2012-2015)
AS 67	Impact of integrated application of organics and inorganics in improving soil health and sugarcane productivity (A.K. Singh, T.K. Srivastava, K.P. Singh and S.R. Singh; Duration : 2015-2018)
Contract research	
DF & PCCL	Studies on the effect of Zinc bensulf on yield and quality of sugarcane (R.R. Verma and S.N. Singh; Duration : 2013-2015, Budget ₹ 6.0 lakh)
CSMCRI	Response of seaweed saps and potassic fertilizer in sugarcane yield (Ishwar Singh; Duration : 03/15-03/16; Budget; ₹ 5.0.lakh)
SDS Remedies	Bioefficacy and phytotoxicity of "Atrazine (50% W) against weeds in sugarcane and its effect on soil health and succeeding crops; Duration : 05/15-04/16)
GEMT	Effect of bio-products on growth, yield and quality of sugarcane and soil health in sub-tropical India (S.K. Shukla; Duration: 2013-15, Budget; ₹ 10 lakh)
Prasmo Agri	Effect of deep gel and nutisap on growth, yield and quality of sugarcane and soil health in subtropical India (S.K. Shukla and S.N. Singh; Duration : 2013-2015, Budget; ₹ 1 lakh)
IPM Labs	Biocontrol testing of biofertilizer 'Hi-brix' in sugarcane (S.K. Shukla and S.N. Singh; Duration : 2013-2015, Budget; ₹ 5 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; Duration : 2014-17; ₹. 7.0 lakh)
Division of Crop Protection	
EM 01	Survey and surveillance of insect-pests and diseases of sugarcane in sub-tropical India (Head, Division of Crop Protection and all scientists of the Division; Duration : 4/06-LT)
M 5.9	Genetic diversity and transmission of pathogen (s) causing Yellow Leaf Disease (YLD) in sugarcane (S.K. Holkar, Arun Baitha and Sanjeev Kumar (Biotech.); Duration : 03/2015-03/2020)
M 5.10	Management of Yellow Leaf Disease (YLD) of sugarcane through thermotherapy (Dinesh Singh and S.K. Holkar, Duration : 05/15-04/18)
M 15.6	Enhancing efficacy of *Trichoderma* based red rot management system (Deeksha Joshi, A.K. Singh and Pushpa Singh; Duration : 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; Duration : 04/12-03/17)
M 17	Evaluation/screening of sugarcane germplam/genotypes against red rot and smut (S.K. Duttamajumder and Ram Ji Lal; 1992-93 to LT)
Ento 2.1	Mechanism of resistance against top borer in sugarcane (M.R. Singh, A. Chandra and A.D. Pathak; Duration : 4/12-3/17)
Ento 4.2	Biological control of sugarcane moth borers, *Pyrilla* and scale insects through exotic and indigenous parasitoids and predators (M.R. Singh and Arun Baitha)
Ento 11.2	Development of techniques of mass multiplication of larval parasitoids for management of sugarcane top borer (Arun Baitha and M.R. Singh; Duration : 04/12-03/17)
Ento 15.1	Containment of major insect-pests of sugarcane through habitat modifications (Arun Baitha and M.R. Singh; Duration : 4/12-3/17)

Project Code No.	Title of the Project
Ento 15.2	Semiochemicals for the management of sugarcane top borer (M.R. Singh and Arun Baitha; Duration : 3/12-2/17)
M 20.1	Genome sequencing of red rot pathogen (S.K.Duttamajumder, Amaresh Chandra, R.K.Singh, Deeksha Joshi amd Nithya, K; Duration : 09/12-02/17)
Externally Funded	
ICAR	Studies on rhizospheric microbial diversity in relation to different sugar profile varieties for growth promotion and disease management (Dinesh Singh; Duration 02/15-02/18)
AICRP (S) Trials	
PP 14	Identification of pathotypes in red rot pathogen (Dinesh Singh, S.K. Dattamajumder and Lalan Sharma; Duration 2002-LT)
PP 17	Evaluation of varieties/genotypes against red rot, smut and wilt (Dinesh Singh, S.K. Dattamajumder and Lalan Sharma; Duration 1984-LT)
PP 22	Survey of sugarcane diseases naturally occurring in the area on important varieties (Dinesh Singh, S.K. Dattamajumder and Lalan Sharma;; Duration -LT)
E 4.1	Evaluation of varieties/genotypes for their reaction against major insect pests (M.R. Singh; Duration : 2002-LT)
E. 30	Monitoring of insect pests and bioagents in sugarcane agro-eco system (M.R. Singh; Duration -LT)
E. 34	Standardization of simple and cost-effective technique for mass multiplication of sugarcane bioagents (M.R. Singh; Duration -03/14-LT)
E. 36	Management of borer complex of sugarcane through lures (M.R. Singh; Duration: 2009-LT)
Contract Research Project	
Bayer	Bioefficacy evaluation of insecticide formulation (Imidaclorid 40%+Fipronil 40% - 80 wg) (M.R. Singh and S.K. Shukla; Duration: 2014-16; Budget: ₹ 7 lakh)
FMC	Bio-efficacy of carbosulfan 6G against top shoot borer (M.R. Singh and S.K. Shukla; Duration: 2014-2016; Budget: ₹ 7.5 lakh)
UPL	Bioefficacy evaluation of insecticide "Lancer Gold" (acephate 50% + imidacloprid 1.8% SP) on sugarcane (M.R. Singh and S.K. Shukla; Duration: 2014-2015; Budget: ₹ 2 lakh)
Parijat	Evaluation of Mortel GR 0.35 (Fipronil 0.35 GR) against early shoot borer, root borer and termites along with the germination and sugar recovery parameter on sugarcane varieties (M.R. Singh and S.K. Shukla; Duration: 2014-2015; Budget: ₹ 1 lakh)
DuPont	Bioefficacy testing of chlorantraniliprole 35 WG against top, stalk and internode borer in sugarcane (Arun Baitha and S.K. Duttamajumder; Duration: 2013-2015; Budget: ₹ 10 lakh)
Plant Physiology and Biochemistry Division	
PB 23	Optimization of plant population for improving physiological efficiency of sugarcane (R.K. Rai, Pushpa Singh, A. Chandra, Radha Jain, A.K. Shrivastava and S.P. Singh; Duration 2/10-3/17)
PB 24	Modulating the expression of sucrose metabolizing enzymes for high sucrose accumulation in sugarcane (Radha Jain and A. Chandra; Duration 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; Duration : 04/12-03/17)
PB 28	Minimizing post- harvest sucrose deterioration and its molecular assessment in sugarcane (A. Chandra and Radha Jain; Duration: 04/12-03/17)
Inter Institutional	Screening and identification of sugarcane lines tolerant to water-logging and their physio-biochemical investigation (Radha Jain and S.P. Singh; Duration : 2013-18)
Externally funded projects	
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

Project Code No.	Title of the Project
	sugarcane (A. Chandra and Radha Jain, Duration : 2013 – 16 (SERB/SR/SO/PS/36/2012)
DST	Down regulation of soluble acid invertase SAI gene to minimize post-harvest sucrose loss through RNAi technology in sugarcane (*Saccharum spp. Hybrid*) (A. Sharma and A. Chandra) (SRI/WOOS-A/LS308/2013) ·
CST UP	Enhancing sugarcane bioproductivity: physiological and metabolic interventions using nutrient-hormonal carriers (Radha Jain, A. Chandra and S.P. Singh; Budget : ₹ 9.0 Lakh, Duration 2015-18)
Contract Research	
Privi	Effect of silica granules on growth, yield and juice quality parameters of sugarcane (Radha Jain and S.K. Shukla; Duration : 2013-15, Budget: ₹5 lakh)
Biodeg	Effect of Biodeg products on biochemical attributes, cane yield and juice quality of sugarcane (Radha Jain, A. Chandra and S.K. Shukla; Duration : 2014-16, Budget: ₹3 lakh)
Privi	Effect of Silixol on growth, yield and juice quality attributes of sugarcane (Radha Jain, A. Chandra and S.K. Shukla; Duration : 2014-16, Budget: ₹5 lakh)
Cytozyme	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)
Agrometerology	
AM5	Impact of climate change on sugarcane insect-pests dynamics and behaviour (M.R. Singh and Rajesh Kumar; Duration: 04/12-03/16)
ICAR Network Project	
NICRA/ IISR	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)
Extension and Training	
ET1.13	Assessment of sugarcane cultivation machines (RMD & RBS planter) on farmers' fields (A.K. Sah, Er. A.K. Singh and R.K. Singh; Duration; 2012-2015)
ET1.14	Entrepreneurship development for sugarcane seed production and multiplication (A.K. Sah, S.N. Singh, Sanjeev Kumar, M.R. Singh and Ramji Lal; Duration : 10/12-10/16)
Agricultural Engineering	
AE9.1	Design refinement of sugarcane-cum-potato planter (Rajendra Gupta and A.K. Singh; Duration 7/12 – 03/17)
AE1.9F	Development of sugarcane harvester for small farms (A.K. Singh and Sukhbir Singh ; Duration : 4/12-3/16)
AE1.22E	Development of modified furrower type sugarcane cutter planter (A.K. Singh and R.D. Singh, Duration : 03/15 – 03/18)
AE1.51	Development of tractor operated sugarcane manager (A.K. Singh and Rajendra Gupta, Duration : 04/12 – 12/15)
AE1.52	Development and evaluation of tractor operated multi-purpose tool framed with attachment for furrow opening fertilizer application spraying interculture and earthing up operation in sugarcane (Sukhbir Singh and Akhilesh Kr. Singh; 10/15-09/18)
AE6.8	Sustaining sugarcane yield under multiratooning through drip irrigation (R. Gupta; 03/16-03/19)
AICRP on FIM Activities	
	Manufacturing of prototypes for conducting field adoptability trials under varying agro-climate and soil conditions (A.K. Singh, Duration : 04/86-LT)
	Prototype feasibility testing (PFT) of Pant-ICAR Sub-soiler-cum-differential rate fertilizer applicator (R.D. Singh,, Sukhbir Singh and A.K. Singh; Duration : 04/15-03/16)

Project Code No.	Title of the Project
	Prototype feasibility testing (PFT) of tractor mounted reaper binder (Sukhbir Singh, R.D. Singh and A.K. Singh, Duration: 04/15-03/16)
	IISR tractor operated deep furrow sugarcane cutter planter (A.K. Singh and Sukhbir Singh; Duration: 04/15 to 03/17)
	IISR tractor operated paired row trench planter (A.K. Singh, Sukhbir Singh and R. Gupta; Duration : 04/15 to 03/17). ICAR Network Project Agri-CRP on Water (Rajendra Gupta, T.K. Srivastava, R.K. Rai, J. Singh, Pushpa Singh, S.R. Singh, R.R. Verma and S.N. Singh; Budget : ₹ 31.00 lakh, Duration : 12/15 – 03/17)
Jaggery Unit	
AE7.6.2	Development of a jaggery furnace with efficiency boosting device (S.I. Anwar; Duration : 4/12-3/17)
AE7.6.3	Optimization of parameters for shelf life enhancement of jaggery under modified atmosphere packaging (Dilip Kumar; Duration: 4/12 – 12/15)
AE7.6.4	Optimizing packaging method for enhancing shelf life of granular jaggery (Prasoon Verma; Duration : 03/15 – 3/17)
AICRP on Post-harvest Technology Activities	
LKO/PHTS/ 11/01	Evaluation of jaggery furnaces (single, double & triple pan) for emission of green house gases and level of bagasse combustion (S.I. Anwar and R.D. Singh; Duration: 04/11-03/16)
LKO/PHTS/ 11/02	Refinement of juice extraction process with special reference to sugarcane cleaning and juice filtration for 100 kg jaggery / 8 hrs (S.I. Anwar & R.D. Singh; Duration: 04/11-03/16)
LKO/PHTS/ 11/03	Development / Adoption of evaporator for sugarcane juice (S.I. Anwar and R.D. Singh; Duration: 04/11-03/16)
LKO/PHTS/ 11/04	Development of power operated jaggery moulding machine (R.D. Singh and S.I. Anwar; Duration: 04/11-03/16)
LKO/PHTS/ 11/05	Development / Adoption of suitable mixer for production of value-added jaggery using *aonla* as a natural source of Vitamin C (S.I. Anwar and R.D. Singh; Duration: 04/11-03/16)
LKO/PHTS/ 12/01	Optimization of parameters for shelf life enhancement of jaggery under modified atmosphere packaging (Dilip Kumar; Duration: 04/12-03/16)
LKO/PHTS 14/01	Value addition of jaggery with Indian spices and herbs for increased market value (S.I. Anwar and Dilip Kumar, Duration : 11/14-10/16)
LKO/PHTS/ 14/02	Development of a semi-automatic jaggery manufacturing plant (Dilip Kumar, Prasoon Verma, S.I. Anwar, G.S. Nevkar amd P.V.K.J. Rao, Duration : 04/14-03/17)
Externally funded project:	
LKO/PHTS/ 13/1	Assessment of post-harvest losses in different crops and commodities in India Funding Agency: Ministry of Food Processing Industries, Govt. of India. (Dilip Kumar, S.I. Anwar and R.D. Singh,; Duration: 04/12 – 03/15)
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)
Economics, Statistics and Computer Application	
AES4.14	Geographic information system of sugarcane and sugar in India (Rajesh Kumar, S.S. Hasan and P.K. Bajpai; Duration : 03/12 – 03/17)
AES4.15	Development of data mining and presentation tools in sugarcane (S.S. Hasan, P.K. Bajpai L.S. Gangwar and Rajesh Kumar; Duration: 04/12 – 03/18)

Project Code No.	Title of the Project
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, Duration : 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., Duration : 04/15 – 03/20)
AES 4.18	Estimation of techno-economical feasibility of sugarbeet cultivation for sugar and ethanol production in India (A.K. Sharma; 10/15-09/17)

* For contract research projects, the name of the firm sponsoring the research has been mentioned.

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Review, Monitoring and Evaluation

QRT Meeting

First meeting of QRT, constituted to review the research work done by Indian Institute of Sugarcane Research, Lucknow; AICRP on Sugarcane and Krishi Vigyan Kendra for the period of 2010-2014 was held on December 7-8, 2015 at the Institute 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, IISR, Lucknow; Dr. Bacchan Singh, Ex. Professor (Agril. Engineering), GBPUA&T, Pantnagar; Dr. Satyavir, Ex. Dean (Agriculture), CCSHAU, Hisar and Dr. R.K. Samantha, Ex. Director, MANAGE & NAARM, Hyderabad were the other members of QRT who were present in the meeting. The meeting was attended by all the scientists of the IISR, Lucknow 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 Incharges made the presentation of their achievements before QRT. The QRT team also visited laboratories and field trials. The Committee appreciated the good work done at the Institute.

XXI Meeting of the Research Advisory Committee

The XXI meeting of Research Advisory Committee (RAC) of the ICAR-Indian Institute of Sugarcane Research (IISR), Lucknow was held on July 7-8, 2015 under the chairmanship of Dr. A.N. Mukhopadhyay, Former VC, AAU, Jorhat. Dr.N. Balasundaram, Ex. Director, SBI, Coimbatore; Dr. D.G. Hapase, Ex-Director, VSI, Pune; Dr. A.S. Patil, Ex.-Director (Research & Extension), VSI, Pune; Dr. Surendra Singh, Ex. Project Coordinator (FIM), Sh. J.L. Jain, GM (Cane), Harinagar Sugar Mills Ltd., West Champaran, Bihar; Dr. O.K. Sinha, Director, IISR, Lucknow; Sh. K.S. Rathi and Sh. S.K. Rana as non-official members and Dr. S.N. Singh, Pr. Scientist as Member Secretary, RAC were the other members who participated in the meeting. The meeting was attended by all the scientists of the Institute.

Dr. A.N. Mukhopadhyay, Chairman, RAC in his opening remarks highlighted the main concerns of sugarcane cultivation in India. He expressed his concern over the grim sugar production scenario of the country. He emphasized the development of farmers' adaptable and low cost technology. The use of IISR developed machineries on custom hiring basis in different parts of the country may be explored. He also urged the scientists to avoid duplication of trials year after year and cut down the number of experiments. Dr. Mukhopadhyay called upon the scientists to select one or two major interdisciplinary farmers' oriented problems of sugarcane research and make time bound programme to solve it.

Dr. O.K. Sinha, the then Director, IISR presented an overview of the R & D activities carried out by the Institute during the last year, with a brief account of the present sugar production scenario in the country. He highlighted that our sugar requirement is 25-26 million tonne. To meet the sugar requirement of the country, we do not have the option to increase the area under sugarcane. The only option to increase the sugar production in the country is by increasing its productivity. Yield can be increased by increasing plant population and planting method.

Dr. S.N. Singh presented the Action Taken Report

on the various recommendations of the previous RAC held during May 28-29, 2014. The Chairman, RAC expressed his satisfaction that most of the points raised in XX meeting of RAC have been addressed.

Dr. A. K. Sharma, Principal Scientist and I/c, PME Cell briefed about the research projects in the Institute, the various monitoring and evaluation mechanisms

for the research activities/projects, Institute Results Framework Document (RFD), Citizen Charter and the major recommendations of QRT and previous RAC, along with the major thrust areas of ICAR. The RAC appreciated these new developments.

The salient research achievements were presented by the Head of Divisions/In-charge Sections/ Programme leaders. Dr. T.K. Srivastava, Head, Division of Crop Production presented the findings related to cane node technology, rhizospheric engineering and other strategies to enhance soil health. Dr. A.D. Pathak, Head, Division of Crop Improvement briefed about the varietal breeding programme, including genetic resource management & pre-breeding, and also the biotechnological interventions for sugarcane improvement. He also presented the R&D efforts in sugarbeet. Dr. Ram Ji Lal, Head, Division of Crop Protection presented the findings related to survey of insect-pests and diseases in sugar mill command areas, pathotyping of *C. falcatum* and bio-control of diseases and insect-pests. Dr. R.K. Rai, Principal Scientist, Division of Physiology & Biochemistry presented biochemical and molecular aspects of high sucrose accumulation *vis-à-vis* post-harvest deterioration in sugarcane. He also presented the efforts to improve the physiological efficiency of sugarcane. Dr. A.K. Singh, HOD (Ag. Engg.) gave an overview of the equipments developed like cutter planter, ratoon manager, RBS, trench planter and paired row planter and the FLDs carried on these equipments. Dr. S.I. Anwar, Principal Scientist & I/c, Jaggery Unit presented the salient achievements pertaining to value-added jaggery prepared by using *aonla*. Dr. P.K. Bajpai, I/c AKMU presented the research work in economics and statistics disciplines. Most of the RAC Members desired that IISR should come forward and develop crop models for cane yield estimation on the basis of cane growth attributes at different months. Dr. Ashok Kumar Shrivastava, I/c Agromet presented the long term behaviour of weather parameters. The achievements of Extension and Training Unit were presented by Dr. A.K. Sah, Principal Scientist & I/c of the unit.

The RAC Members visited experimental fields and various laboratories on July 8, 2015 and appreciated the conduct of field experiments and the general maintenance & upkeep of the experimental farm and Institute buildings which was superb. Several recommendations were made by the RAC.

IRC Meeting

IRC meetings were held on October 13-15, 2015 under the chairmanship of Dr. T.K. Srivastava, Director, IISR. During three days of deliberations in the meeting, 53 Institute research projects were reviewed, five new project proposals were approved, and six research projects were concluded.

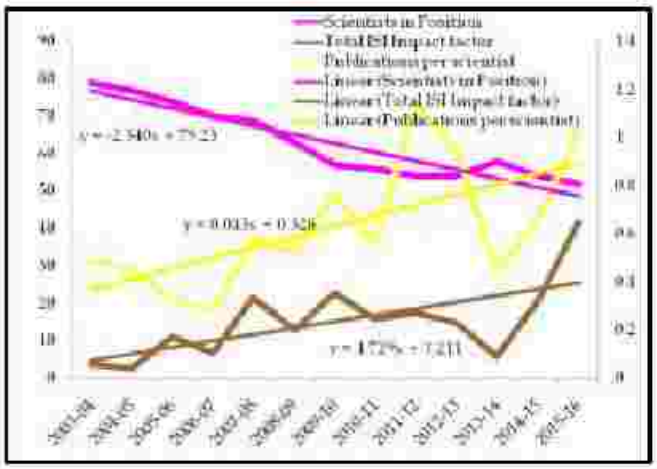
Division/ Section	Inter-Institutional	Institute	Network	Contract research	Externally funded	Total	AICRP Research Activities
Crop Improvement	-	17	2	-	4	23	*(3)
Crop Production+ SWAPM	-	7	-	8	2	17	*(6)
Plant Physiol & Biochem	1	5	-	4	3	13	-
Crop Protection	-	11	-	5	1	17	*(8)
Agril. Engineering	-	5	1	-	-	6	# (5)
Jaggery unit	-	3	-	-	-	3	$ (10)
Eco/Stat/AKMU/PME	-	5	-	-	-	5	-
Ag. Meteorolgy	-	1	1	-	-	2	-
Extension Unit	-	3	-	-	-	3	-
Total	1	57	4	17	10	89	3 (32)

* = AICRP on Sugarcane, # = AICRP on FIM, $ = AICRP on PHT

b) Database on Institute Publications was developed

Year	NAAS rating score	ISI impact factor
2003-04	135.3	3.982
2004-05	121.77	2.779
2005-06	361.45	11.124
2006-07	83.31	6.95
2007-08	454.76	21.593
2008-09	139.18	13.025
2009-10	176.06	22.786
2010-11	153.53	15.96
2011-12	277.92	17.487
2012-13	495.58	14.874
2013-14	340.05	5.953
2014-15	200.85	20.948
2015-16	302.76	41.664

Source : PME Cell, ICAR-IISR, Lucknow



XXXIX Meeting of IMC

Thirty ninth meeting of Institute Management Committee was held on December 5, 2015 under the chairmanship of Dr. A.D. Pathak, Director. Progress of R & D efforts was reviewed and various administrative matters were discussed.

Institute Technology Management Committee Meeting

The meeting of Institute Technology Management Committee was held on November 16, 2015 under the chairmanship of Dr. T.K. Srivastava, Director. Three technologies in IRC Meeting held on October 13-15, 2015 were presented by the PIs for their commercial exploitation. Interface Meeting with Industry was also organized in which, an industrial representative gave positive feedback on the potential of sugarcane machineries developed by the Institute, particularly in Uttar Pradesh. He highlighted that Institute developed machines are being manufactured by his firm. He, however, emphasized the need for subsidies on these costly machines for promoting the mechanization of sugarcane cultivation. All contract research projects were reviewed for their progress in the meeting.

IBSC Meeting

A meeting of the Institutional Biosafety Committee (IBSC) of the Institute was held on May 6, 2015 under the Chairmanship of Dr. O.K. Sinha, Director, ICAR-IISR. The meeting was attended by Dr. Amaresh Chandra, Head, Division of Plant Physiology & Biochemistry, ICAR-IISR; Dr. Sangeeta Srivastava, Principal Scientist, Division of Crop Improvement, ICAR-IISR; Dr. Neelam S. Sangwan, Senior Scientist, CSIR-CIMAP; Dr. S.K. Sethi, Medical Officer, ICAR-IISR; Dr. A.K. Sharma, Principal Scientist & I/c PME Cell; Dr. R.K. Singh, Principal Scientist, Division of Crop Improvement, ICAR-IISR; Dr. Sanjeev Kumar, Senior Scientist, ICAR-IISR; Dr. Somnath K. Holkar, Scientist, Division of Crop Protection, ICAR-IISR and Dr. M. Swapna, Principal Scientist, Division of Crop Improvement and Member Secretary of the committee. Various biosafety measures were discussed in the meeting. Dr. O.K. Sinha emphasized upon the need for the use of cutting edge technologies including transgenic research in improving the sugarcane productivity and sugar recovery, keeping in mind the future demands for sugar and other products. He remarked that all research workers should observe the biosafety measures and hazardous chemicals should be disposed of as per prescribed manners.

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Participation in Seminars/Symposia/Conferences

Participation of IISR Staff in Seminars/Symposia/Conferences

Name	Conference/Seminar/Symposia	Venue	Date
Drs. R.D. Singh and S.I. Anwar	Workshop on "Making engineering scientists' contribution more meaningful to stakeholders and the nation"	New Delhi	April 13-14, 2015.
Dr. R.K. Singh	Training Workshop on "Monitoring Confined Field Trials of Regulated GE Plants" organized by Ministry of Environment, Forest & Climate Change, Govt. of India	NASC Complex, New Delhi	May 25-26, 2015
Drs. S.K. Shukla, A.K. Sah, S.K. Awasthi and Sh. Brahm Prakash	3rd UP Agricultural Science Congress on Strategic Governance and Technological Advancement for Sustainable Agriculture	SHIATS, Allahabad	June 14-16, 2015
Dr. P.K. Singh	National Seminar on "Take it to Farmers-The Farmers' Rights through Awareness"	NASC Complex, Pusa, New Delhi	July 7, 2015
Dr. S.K. Shukla	Launching Workshop of AICRP on Micronutrient	AAU, Anand	July 9. 2015
Drs. Amaresh Chandra, Rajesh Kumar Singh (KVK), Radha Jain	National Conference on KVK and ICAR Foundation Day Ceremony	Patna	July 25-26, 2015
Dr. A.K. Sharma	First Workshop of Nodal Officers of ICAR Research Data Repository for Knowledge Management Initiative	NASC Complex, Pusa, New Delhi	July 2016
Dr. Ram Kewal Singh	National Symposium on Germplasm to Gene : Harnessing Biotechnology for Food Security and Health	NASC Complex, Pusa, New Delhi	August 9-11, 2015
Drs. A.K. Shrivastava, Rajesh Kumar	4th Annual Workshop of NICRA Training Programme on Analysis of Experimental Data	CMFRI, Cochin NAARM, Hyderabad	August 13-14, 2015 August 17-22, 2015
Dr. A.K. Sah	Technical session organized during National Agricultural Exhibition at the occasion of Inauguration of NRC on Integrated Farming System Research Institute	*Pipara Kothi, Motihari, East Champaran (Bihar)*	August 20-21, 2015
Drs. O.K. Sinha, T.K. Srivastava, A. Chandra, M. Swapana, A.K. Sharma, A. Baitha	Brain Storming Seminar on Harnessing energy feedsocks for sustainability of sugar industry in sub-tropical India	ICAR-IISR, Lucknow	August 22, 2015
Drs. P.K. Singh and Sanjeev Kumar	10th Annual Review Meeting of ICAR Seed Project "Seed Production in Agricultural Crops"	ICAR Research Complex, Goa	August 24-25, 2015

Name	Conference/Seminar/Symposia	Venue	Date
Drs. S.K. Shukla, S.N. Singh, A.K. Singh, A.K. Sah and A.K. Singh	XI Joint Convention of STAI and DSTA	S.P. Mukherjee Indoor Stadium, Goa	September 4-6, 2015
Dr. M.M. Roy	Brain Storming Session on Augmenting Forage Resources in Rural India : Policy Issues and Strategies organized by NAAS	NASC Complex, Pusa, New Delhi	September 7, 2015
Dr. P.K. Singh and Sh. Abhishek Kumar Singh	10th *Vishwa Hindi Sammelan*	Bhopal	September 10-12, 2015
Er. A.K. Singh and Dr. L.S. Gangwar	Farmers –Scientists-Industry Interaction o n "Current Scenario and Future Challenges in Sugarcane under Sub-tropics"	CCSHAU RRS, Uchani, Karnal	September 15, 2015
Dr. A.D. Pathak	Meeting of Stakeholders of NRC on Integrated Farming System	ICAR-RCER, Patna	September 17, 2015
Dr. A.K. Shrivastava	26th Meeting of Sugarcane Research and Development Workers of Andhra Pradesh	Agricultural University, Vishakhapatnam	September 21-22, 2015
Dr. V.P. Singh	25th Asia Pacific Weed Science Society Conference on "Weed Science for Sustainable Agriculture, Envi ronment and Biodiversity" organized by Indian Society of Weed Science	The Professor Jayashankar Telangana State Agricultural University (PJTSAU), Hyderabad	October 13-16, 2015
Dr. T.K. Srivastava and Dr. A.K. Shrivastava	Interface meeting on Way forward to adaptation and development of drought tolerant sugarcane varieties in India in the wake of GM drought tolerant variety developed in Indonesia	ICAR-IARI, New Delhi	October 20, 2015
Dr. S.K. Shukla	Workshop of Vigilance Officers	NASC, New Delhi	October 27-28, 2015
Drs. A.K. Sah, V.K. Singh, Rajesh Kumar, Singh and Rakesh Kumar Singh	ISEE Golden Jubilee National Seminar on Strategy to Drive Skill based Agriculture Development forward for Sustainability and Rural Employability	IAS, BHU, Varanasi	November 5-7, 2015
Dr. Ram Kewal Singh	9th Annual Review Meeting of NPTC Project	ICAR-NRCPB, New Delhi	November 7, 2015
Dr. A.K. Sharma and Sh. Brahm Prakash	75th Annual Conference of the Indian Society of Agricultural Economics	PAU, Ludhiana	November 19-21, 2015
Drs. M.M. Roy D.R. Malviya and Rakesh Kumar Singh	23rd International Grassland Conference, 2015	Vigyan Bhawan, New Delhi and Hotel Leela, Gurgaon	November 20-24, 2015
Dr. D.R. Malviya	Workshop on "Regional Consultation on Sustainable Grassland and Pasture Management in Asia	Lanzhou University, China	November 27-30, 2015
Dr. Dilip Kumar	Group meeting on Mechanization of Jaggery Industry of AICRP on PHET Centres (Jaggery Sector)	Anakapalli	November 17, 2015
Dr. L.S. Gangwar	National Seminar entitled "Financing Agriculture Value Chains : Challenges and Opportunities"	BIRD, Lucknow	November 29-30, 2015
Drs. A.K. Sharma and L.S. Gangwar	23rd Annual Conference of the Agricultural Economic Research Association (India), New Delhi on "Inter and Intra -Sectoral Dynamics for Transforming Indian Agriculture	ICAR-CIFE, Mumbai	December 2-4, 2015
Dr. A. Chandra	3rd International Plant Physiology Congress on Challenges and Strategies in Plant Biology Research	JNU, New Delhi	December 11-14, 2015
Dr. A.D. Patahk and all the scientists of the Institute	National Workshop of *Unnat Bharat Abhiyan* on Natural Farming and Cow - based Economy organised by during and held at ICAR-IISR, Lucknow	ICAR- Indian Institute of Sugarcane Research, Lucknow	December 12-13, 2015

Name	Conference/Seminar/Symposia	Venue	Date
Drs. Amaresh Chandra and Radha Jain	3rd International Plant Physiology Conference	JNU, New Delhi	December 13-15, 2015
Drs. A.D. Pathak, O.K. Sinha, C. Gupta, Rajesh Kumar, Ramji Lal, T.K. Srivastava, S.K. shukla A.K. Singh, S.N. Singh, J. Singh, P.K. Singh, Sanjeev Kumar, M.R. Singh, Dinesh Singh, S.R. Singh, R.R. Verma, G.K. Singh and Adil Zubair	31st Group Meet of AICRP on Sugarcane	RAU, Pusa, Samastipur, Bihar	December 15-16, 2015
Dr. Rakesh Kumar Singh	National Dialogue on Innovative Extension System to Farmers Empowerment and Welfare	NASC Complex, New Delhi	December 17-19, 2015
Dr. S.K. Holkar	National Symposium-cum-Mid Eastern Zonal Meeting on Impact of Climate Change on Plant-Microbe Interactions and its Implications	BHU, Varanasi	December 18-19, 2015
Dr. Dinesh Singh	Expert Consultation meeting on "Endophytes: Status and Prospectus in Agriculture"	ICAR-National Bureau of Agriculturally Important Microorganism, Kushmaur, Mau	December 23, 2015
Dr. Ishwar Singh	2nd International Conference on Agriculture, Horticulture and Plant Sciences	Hotel Landmark, Shimla	December 26-27, 2015
Drs. S.I. Anwar and Dilip Kumar	31st Annual Workshop of AICRP on PHET	TNAU, Coimbatore	January 03-06, 2016
Dr. A.K. Sah	International Seminar on Indigenous technologies for sustainable agriculture and better tomorrow	CSIR-NBRI, Lucknow	January 09-10, 2016
Drs. A.D. Pathak, A.K. Singh, R.D. Singh, S.I. Anwar, Dilip Kumar, Prasoon Verma, A.K. Sah	Workshop on "Engineering Interventions for Increasing Agricultural productivity, farmers' Income and employment Generation"	ICAR-IISR, Lucknow.	February 02, 2016
Drs. A.D. Pathak and A.K. Sah	Launching Programme on International Year of Pulses	ICAR-IIPR, Kanpur	March 13, 2016
Dr. Swapna M.	National Workshop on "Current Trends in Bioinformatics and its Applications in Agriculture"	ICAR-NAARM, Hyderabad	February 15-17, 2016
Drs. S.K. Shukla, S.N. Singh, Brahm Prakash, Vineeka Singh, Deepak Rai and V. Singh	4th National Symposiom on Transforming Indian Agriculture towards Food and Nutritional Security	ICAR-IGFRI, Jhansi	February 20-21, 2016
Dr. Dinesh Singh , Dr. Deeksha Joshi and Dr. S.K. Holkar	6th International Conference on " Plant Pathogens and People": Challenges in Plant Pathology to Benefit Humankind"	ICAR-IARI, New Delhi	February 23-27, 2016.
Drs. S.K. Shukla, Chandra Gupta, A.K. Singh, A.K. Sah and Mr. Brahm Prakash	4th UP Agricultural Science Congress	CSA University of Agriculture & Technology, Kanpur	March 2-4, 2016

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Events organised

Seminar on "Harnessing energy feed stocks for sustainability of sugar industry in sub-tropical India"

Brainstorming Seminar was organized jointly by ICAR-Indian Institute of Sugarcane Research, Lucknow, North Indian Sugarcane & Sugar Technologists' Association of India and Directorate of Sugarcane Development, Govt. of India on 22nd August, 2015 at IISR, Lucknow, to deliberate upon the possible ways and means to sustain the sugar industry through diversification. Dr P.K. Seth, CEO, Biotech Park, Lucknow was the Chief Guest.

In his welcome address, Dr. O.K. Sinha, Director, IISR stressed upon the current problems faced by the sugar industry and an urgent need for diversification to bio-ethanol and bio-energy using alternate feedstocks like sugar beet. Dr Ram Murty Singh, President, NISSTA; Shri.K.P. Singh, Executive President, Balrampur Sugar Group; Dr. M.C. Diwakar, Director, Directorate of Sugarcane Development; Mr. A.K. Shukla, General Secretary, NISSTA, Dr. Bakshi Ram, Director, Sugarcane Breeding Institute, Coimbatore and others spoke about the need for diversification in the industry. Dr. Narendra Mohan, Director, National Sugar Institute (NSI), Kanpur, in his keynote address, emphasized upon dual pricing of sugar for domestic and commercial market, effective branding and packaging of sugar, integrated complexes, B-heavy molasses for ethanol production and better Industry-Research Institute collaborations.

In technical Session, view points on various ways of ethanol production using feedstocks like sugar beet and cassava, apart from sugarcane were discussed. The possibility of making second generation (2G), third generation (3G) and fourth generation (4G) ethanol from non-edible plant parts, from algae and from genetically engineered organisms, respectively, was discussed by Dr. Pushpa Singh, Principal Scientist, IISR, in her lead lecture "Ethanol Production, Emerging Technologies and Sustainability Issues".

Seminar on Sustainable Agriculture in Climate Change Scenario

A Seminar on Sustainable Agriculture in Climate Change Scenario was organized under the aegis of NEFORD and ICAR-Indian Institute of Sugarcane Research, Lucknow on March 19, 2016. It

was recommended that crop varieties tolerant to heat and salinity stress and resistant to flood and drought have already been developed and these varieties need to be promoted at faster speed following innovative transfer of technology approaches. There is need to promote climate-ready crop varieties, energy, water, labour, time and cost saving improved crop management practices in big way.

In the changing climate scenario and growing instability in agriculture, community managed efforts could be more effective. Promotion of agro - forestry and horticultural trees and high biomass food and non-food crop diversity for higher CO_2 sequestration and moderating farm temperature will also help in maintaining different strata of soil moisture as well as soil bio-diversity.

National Workshop on Organic Farming and Cow-based Economy

National Workshop on Organic Farming and Cow-based Economy under the aegis of *Unnat Bharat*

Abhiyan of the Govt. of India was held at ICAR-IISR, Lucknow on December 12-13, 2015. Dr. Sanjeev Kumar Baliyan, Hon'ble Minister of State for Agriculture and Farmer Welfare, Govt of India; Sh. Yogi Adityanath, Hon'ble Member of Parliament; Smt. Krishna Raj, Hon'ble Member of Parliament; Dr. N.S. Rathore, DDG (Education), ICAR and Dr. M.B. Chetti, ADG (HRI graced the c

Workshop on Engineering Interventions

Lucknow Chapter of the Indian Society of Agricultural Engineering and ICAR-Indian Institute of Sugarcane Research, Lucknow jointly organized one-day workshop on "Engineering Interventions for increasing Agricultural Productivity, Farmers' Income and Employment Generation" at ICAR-IISR, Lucknow, on February 02, 2016. The workshop was convened by Dr.S.I. Anwar, Principal Scientist at the Institute. At this occasion, Annual General Body Meeting of Lucknow Chapter of Indian Society of Agricultural Engineering was also organized.

World Food Day

World Food Day was celebrated at the Institute on October 16, 2015. On this day, improved production technology was demonstrated to the farmers of adjoining districts. *Ganna Taknik Pradarshani Evam Kishak Goshthi* and Seed Production Awareness Programme was organized on this occasion.

On the occasion of World Food Day on October 16, 2015, Seed Awareness Programme was organized at ICAR-IISR. In this programme, 200 farmers from different districts of Uttar Pradesh were provided with seed packets of newly released variety, CoLk 9709 and a campaign was initiated for making the sugarcane growers aware about the role of quality seed cane in enhancing the yield and production. Under '*Mera Gaon, Mera Gaurav*' Scheme also, quality seed cane was a major component for the awareness.

World Soil Health Day

Krishi Vigyan Kendra, Lucknow organized a programme on December 5, 2015 on the occasion of Soil Health Day during International Soil Year-2015 at ICAR- Indian Institute of Sugarcane Research, Lucknow. The Main focus of this programme was distribution of about 300 soil health cards, technical sessions, farmers-scientist interaction, and farmers' feedback. Programme was inaugurated by the Chief Guest, Dr. K.N. Tiwari, Ex. Professor and Head, Soil Science and Agricultural Chemistry, CSAUA&T, Kanpur and presided over by Dr. A.D. Pathak, Director, IISR, Lucknow. Welcoming the dignitaries and farmers, Dr. A.D. Pathak, Director, ICAR-IISR focussed on developed technology of sugarcane and linked farmers for its dissemination at farmers fields. In the introductory remarks, Dr. K.P. Singh emphasized on the testing of soil samples and explained the programmes chalked out by the Government for soil health cards. Chief guest, Dr. K.N.

Tiwari gave valuable remarks on sustaining soil health, concept of integrated nutrient management, soil fertility and productivity and use of vermi-compost and green manuring. Dr. K.P. Singh, Head, KVK proposed the vote of thanks to all.

Jai Kisan Jai Vigyan Week

Jai Kisan Jai Vigyan Week was celebrated from December 23-29, 2015 under which number of the teams of the scientists visited number of villages adopted under '*Mera Gaon Mera Gaurav*' (MGMG) Scheme, interacted with them and made them aware of the Institute technologies. The programme was concluded on December 29, 2015 in which farmers from nearby districts shared their success stories with fellow farmers and were felicitated. The team leaders of each team of MGMG made the presentation of their visits and activities in the adopted villages.

National Science Day

National Science Day was celebrated at the Institute on February 28, 2016. On this occasion, Dr. M.M. Roy, Principal Scientist, Division of Plant Physiology and Biochemistry delivered a talk on "Water : Status, Issues and Options for Agricultural Use in India", which was attended by all the Scientists, Technical, Administrative, Research Associates, Research Fellows, Ph.D./PG/UG students and trainees.

IISR Foundation Day

The 65th Foundation Day of ICAR-Indian Institute of Sugarcane Research was celebrated on February 16, 2016. Dr. S. Solomon, Former Director, IISR was the Chief Guest on the occasion. In his address, Dr. Sushil Solomon highlighted the need for developing suitable technologies for reducing the water requirement of sugarcane and also emphasised on carbon sequestration and carbon trading. Highlighting the present accomplishments of the Institute, Dr. A.D. Pathak, Director informed that two genotypes developed by the Institute have shown promise in the All India Coordinated trials and are expected to release soon. He also added that thirteen genotypes developed by the IISR are in various stages of testing under AICRP on Sugarcane. He expressed satisfaction over increased yield of sugarcane in Uttar Pradesh from 60 to 65 t/ha along with the sugar recovery over 11 per cent. Similarly, the yield of sugarcane has also been increased in neighbouring state of Bihar to 62 t/ha from 46 t/ha due to seed production programme being executed by the Institute. Dr. Pathak informed that 64 villages have

been adopted under *Mera Gaon Mera Gaurav* programme of Govt. of India and the farmers of these villages are reaping benefits of adopting improved production technologies.

Dusshera Mela

Dashehra Mela was organized at Ikshupurri-the residential colony of the Institute. The Mela was inaugurated by Dr. T.K. Srivastava, Director, IISR. On this occasion, events like volleyball match, musical chair, Ram Lila and the burning of effigy of Ravana were major attractions.

Hindi Pakhwara

Hindi Pakhwara was celebrated at the Institute during Sept. 14-30, 2015. Dr. S. Rajan, Director, ICAR-CISH, Lucknow, the Chief Guest on the occasion urged the Scientists and Staff to do all of their work in Hindi. Dr. Rajan added that there is no competition between Hindi and any other regional language of the country. Rather than that, Hindi language has helped

in unity and integrity of the country as a contact language keeping cooperation of all the regional languages. Dr. T.K. Srivastava, Director of the Institute 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 questionnaire based on general knowledge in Hindi were organized, in which staff of IISR participated. A shield entitled "Mithas" was presented to the IISR-Krishi Vigyan Kendra, Lucknow for doing maximum work in Hindi.

Hindi Workshops

Four Hindi Workshops were organized during the year 2015-16 viz., June 28, 2015; September 23, 2015; November 30, 2015 and March 29, 2016 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 2015 was organized at the Institute on June 28, 2015 under the chairmanship of Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow. The second meeting for the year was held at the Institute on November 30, 2016 under the chairmanship of Dr. T.K. Srivastava, 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.

NET/ARS-Preliminary 2015 examination

Agricultural Scientist Recruitment Board (ASRB), New Delhi in search of talent in agricultural research services regularly conducts various examinations all over India. It has now developed a network of Online Examination Centres at 23 places to ease the process of evaluating candidates in various disciplines of agricultural sciences. Recently, an online examination of NET/ARS-Preliminary 2015 was held at ICAR-IISR, Lucknow centre. It was organized in three slots per day during 4-10 December, 2015. Out of 1768 candidates allotted to the centre in various disciplines, 1320 candidates took the examination at the ICAR-IISR Centre. The examination was successfully completed with active role of AKMU.

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Distinguished Visitors

Name and Designation	Date of visit
Ministers and Members of Parliament	
Dr. Sanjeev Kumar Baliyan, Hon'ble Minister of State for Agriculture, Govt. of India	June 20, 2015
Shri Kaushal Kishore, Hon'ble Member of Parliament	July 11, 2015
Dr. Sanjeev Kumar Baliyan, Hon'ble Minister of State for Agriculture, Govt. of India	December 12, 2015
Sh. Yogi Adityanath, Hon'ble Member of Parliament	December 13, 2015
Smt. Krishna Raj, Hon'ble Member of Parliament	December 13, 2015
Sh. Radha Mohan Singh, Hon'ble Minister of Agriculture and Farmers Welfare, Govt. of India	December 28, 2015 & March 05, 2016
ICAR Dignitaries	
Dr. T. Mohapatra, Secretary, DARE and Director General, ICAR, New Delhi	March 05, 2016
Sh. R. Rajagopal, Additional Secretary, DARE and Secretary, ICAR, New Delhi	September 19, 2015
Dr. J.S. Sandhu, Deputy Director General (Crop Science), ICAR, New Delhi	March 05, 2016
Dr. N.S. Rathore, Deputy Director General (Ag. Education), ICAR, New Delhi	December 12-13, 2015
Dr. M.B. Chetti, ADG (HRD), ICAR, New Delhi	December 12-13, 2015
Vice-Chancellor, Civil Servants and Directors	
Dr. A.N. Mukhopadhyay, Former VC, AAU, Jorhat	July 7-8, 2015
Dr. N. Balasundaram, Ex. Director, ICAR-SBI, Coimbatore	July 7-8, 2015
Dr. U.S. Gautam, Director, ATARI (Zone-IV) , Kanpur	July 11, 2015
Dr. S. Rajan, Director, ICAR-Central Institute of Sub-tropical Horticulture, Lucknow	July 11, 2015
Dr. M.C. Diwaker, Director, Directorate of Sugarcane and Development, Ministry of Agriculture and Farmers Welfare, Govt. of India	July 11, 2015
Sh. Zubair Hashmi, IAS, Special Secretary, Food Security and Medicine Administration , U.P. Govt.	September 15, 2015
Dr. S. Rajan, Director, ICAR-Central Institute of Sub-tropical Horticulture, Lucknow	September 30, 2015
Mr. S.N. Sawant, IPS, Addl. Director General, UP Police Recruitment Board, New Delhi	October 26, 2016
Sh. Habibul Hasan, Superintendent of Police (Traffic), Lucknow	November 30, 2015
Dr. J.B. Chaudhary, Ex. Vice-Chancellor, G.B. Pant University of Agriculture and Technology, Pantnagar	December 7-8, 2015
Dr. N. Vijayan Nair, Ex. Director, ICAR-SBI, Coimbatore	December 7-8, 2015
Dr. S.R. Singh, Ex. Vice-Chancellor, Rajendra Agricultural University, Samastipur	March 18, 2016
Foreign Visitors	
Mr. Paul Frost, Commercial Officer, US Commercial Service	August 20, 2015
Mr. Subiyono, President & Director of PTPN X (Sugar Mill), Indonesia	February 19, 2016
Mr. Yaga Govender, President, National Cane Growers Association, South Africa	February 25, 2016
Other Distinguished Visitors	
Dr. D.G. Hapase, Ex-Director, VSI, Pune	July 7-8, 2015

Name and Designation	Date of visit
Dr. A.S. Patil, Ex.-Director (Research & Extension), VSI, Pune	July 7-8, 2015
Dr. Surendra Singh, Ex. Project Coordinator (PIM), ICAR-CIAE, Bhopal	July 7-8, 2015
Sh. J.L. Jain, GM (Cane), Harinagar Sugar Mills Ltd., West Champaran, Bihar	July 7-8, 2015
Dr. Jitendra Nath Pandey, Ex. Professor, Hindi Department, University of Lucknow, Lucknow	September 15, 2015
Dr. (Mrs.) Himanshu Sen, Associate Professor, Hindi Department, University of Lucknow, Lucknow	September 30, 2015
Prof. U.N. Dwivedi, Pro-Vice Chancellor, University of Lucknow, Lucknow	September 23, 2015
Dr. Sushil Kumar Rai, Programme Executive, Akashwani, Lucknow	September 23, 2015
Dr. S.P. Dixit, Ex. Head, Department of Hindi, University of Lucknow, Lucknow	September 23, 2015
Dr. Pawan Agarwal, Professor, Hindi Department, University of Lucknow, Lucknow	November 30, 2015
Dr. K.N. Tiwari, Ex. Professor and Head, Soil Science and Agricultural Chemistry, CSAUA&T, Kanpur	December 5, 2015
Dr. D.C. Upreti, Ex. National Fellow, IARI, New Delhi	December 7-8, 2015
Dr. Bacchan Singh, Ex. Professor (Agril. Engineering), GBPUA&T, Pantnagar	December 7-8, 2015
Dr. Satyavir, Ex. Dean (Agriculture), CCSHAU, Hisar	December 7-8, 2015
Mr. Umesh Verma, Development Coordinator, Agronomy & Business Management, Cytozyme Sustainable Nutritional Solutions	February 22, 2016

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Personnel

(As on March 31, 2016)

Director	:	Dr. A.D. Pathak
Crop Improvement		
Principal Scientist & Head	:	Dr. A.D. Pathak
Principal Scientist (Plant Breeding)	:	Dr. Raman Kapur
	:	Dr. D.R. Malaviya
	:	Dr. Jyotsnendra Singh
	:	Dr. D.K. Pandey
	:	Dr. P.K. Singh
	:	Dr. Sanjeev Kumar
	:	Dr. Vinod Kumar Gupta
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
Technical Officers	:	Smt. Hem Lata Madhok, Mr. C.P. Singh, Mr. Raghvendra Kumar, Mr. Ram Kumar Gautam, Mr. Ram Murty, Mr. Ram Sewak
Crop Production		
Principal Scientist & Head	:	Dr. S.K. Shukla
Principal Scientist (Agronomy)	:	Dr. K.P. Singh
	:	Dr. S.N. Singh
	:	Dr. V.P. Singh
	:	Dr. A.K. Singh
Principal Scientist (Agril. Extension)	:	Dr. R.S. Dohare
Senior Scientist (Agronomy)	:	Dr. Ishwar Singh
Senior Scientist (Agril. Extension)	:	Mr. Kamta Prasad (On study leave)
Scientist SS (Soil Science)	:	Dr. Ram Ratan Verma
Technical Officers	:	Dr. R.K. Singh, Mr. Anil Kumar Singh, Mr. S.N. Srivastava
Crop Protection		
Principal Scientist & Head	:	Dr. Maharam Singh
Principal Scientist (Plant Pathology)	:	Dr. S.K. Duttamajumder
	:	Dr. Anil Kumar Singh
Principal Scientist (Agril. Entomology)	:	Dr. S.N. Sushil (On deputation)
	:	Dr. Arun Baitha
Principal Scientist (Plant Pathology)	:	Dr. Dinesh Singh
Sr. Scientist (Plant Pathology)	:	Dr. Deeksha Joshi
Scientist (Plant Pathology)	:	Mr. S.K. Holkar
	:	Mr. Lalan Sharma
Technical Officers	:	Dr. D.C. Rajak (On deputation), Dr. Anoop Singh Sachan, Smt. Pramila Lal, Mr. B.L. Maurya, Mr. I.P. Maurya, Mr. M.P. Sharma,

Plant Physiology & Biochemistry

Principal Scientist & Head	:	Dr. Amresh Chandra
Principal Scientist (Plant Physiology)	:	Dr. A.K. Shrivastava
Principal Scientist (Economic Botany & Plant Genetic Resources)	:	Dr. M.M. Roy
Principal Scientist (Plant Physiology)	:	Dr. R.K. Rai
	:	Dr. Radha Jain
Principal Scientist (Organic Chemistry)	:	Dr. Pushpa Singh
Senior Scientist (Plant Physiology)	:	Dr. S.P. Singh
Technical Officers	:	Mr. Sanjay Bhatnagar, Dr. Namita Arya, Mrs. Anita Sawnani (On study leave), Dr. Ram Kishor, Mr. Somendra Prasad Shukla, Mr. R.K. Singh

Agricultural Engineering

Principal Scientist & Head	:	Dr. A.K. Singh
Principal Scientist (Farm Mach. & Power)	:	Dr. R.D. Singh
Senior Scientist (Soil Water Cons. Engg.)	:	Dr. Rajendra Gupta
Senior Scientist (FMP)	:	Er. Sukhbir Singh
Technical Officers	:	Mr. Jasbir Singh, Mr. Suresh Kumar Kushwaha, Mr. Chaman Singh, Mr. Julianus Minz, Mr. Someshwar Mishra, Mr. Surya Dev Singh

Jaggery Unit

Principal Scientist and Incharge	:	Dr. S.I. Anwar
Scientist (SG) (AS &PE)	:	Er. Prasoon Verma
Senior Scientist (AS &PE)	:	Dr. Dilip Kumar
Technical Officer	:	Mrs. Mithilesh Tiwari, Mr. Sunil Kumar Mishra

PME Cell & Institute Technology Management Unit

Nodal Officer & Incharge	:	Dr. A.K. Sharma
Technical Officer	:	Mr. Brahm Prakash and Mr. Atul Kumar Sachan

AKMU

Principal Scientist & Incharge	:	Dr. L.S. Gangwar
Senior Scientist (Computer Application)	:	Dr. S.S. Hasan
Technical Officer	:	Dr. Mani Ram Verma

Agrometeorology

Principal Scientist & Incharge	:	Dr. T.K. Srivastava
Senior Scientist		Dr. V.K. Singh
Technical Officer	:	Mr. Surendra Singh

Soil, Water, Plant Analysis and Microbiology Laboratory

Principal Scientist & In-Charge	:	Dr. S.K. Shukla
Technical Officer	:	Mrs. Asha Gaur

Juice Lab

Principal Scientist & In-Charge	:	Dr. A.K. Shrivastava
Technical Officer	:	Mrs. Meena Nigam and Dr. Om Prakash

Extension & Training Unit

Principal Scientist & In-Charge	:	Dr. A.K. Sah
Technical Officer	:	Mr. Nar Singh and Mr. A.K. Singh

AICRP on Sugarcane

Project Coordinator	:	Dr. O.K. Sinha
Principal Scientist (Agril. Statistics)	:	Dr. Rajesh Kumar
Principal Scientist (Agronomy)	:	Dr. Chandra Gupta
Technical Officer	:	Dr. G.K. Singh, Sh. Devendra Singh, Mr. Adil Zubair

Farm Section

Principal Scientist & In-charge	:	Dr. A.K. Singh
Farm Managar	:	Mr. B.B. Joshi,
Technical Officers	:	Mr. B.B. Singh, Mr. Faujdar Singh, Sh. Vishwanath Ram

Krishi Vigyan Kendra

Principal Scientist & I/c	:	Dr. S.N. Singh
SMS (Animal Science)	:	Dr. Rakesh Kumar Singh
SMS (Home Science)	:	Dr. (Smt.) Veenika Singh
SMS (Plant Protection)	:	Dr. Deepak Rai
SMS (Agronomy)	:	Dr. Rakesh Kumar
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

Arts & Photography

Principal Scientist & In-Charge	:	Dr. A.K. Sharma
Technical Officers	:	Mr. Vipin Dhawan, Mr. Y.M. Singh, Mr. Avadhesh Kumar Yadav

Dispensary

In-charge	:	Mr. Ratnesh Kumar
Medical Officer	:	Dr. S.K. Sethi
Technical Officer	:	Mr. D.N. Sinha

Library

Principal Scientist & In-Charge	:	Dr. L.S. Gangwar
Technical Officer	:	Mr. Ghanshyam Ram & Mr. R.N.P. Bharti
In-Charge, Seed Production Unit	:	Dr. Sanjeev Kumar
In-Charge, Vehicle	:	Mr. Raj Kumar
In-Charge, Landscaping	:	Mr. Deep Kumar
In-Charge, Guest House	:	Mr. Ratnesh Kumar
Manager, Guest House	:	Mr. Nag Chand

Estate & Maintenance

In-Charge	:	Mr. M.H. Ansari
Technical Officer	:	Mr. Vinayak Sawant, Mr. Krishna Nand Singh, Mr. Lakhan Lal Verma, Mr. Umesh Kumar, Mr. Vishva Nath Mehrotra

ICAR-IISR Regional Centre, Motipur (Bihar)

Senior Scientist (Agronomy) & In-charge	:	Dr. V.P. Jaiswal

Administration

Senior Administrative Officer	:	Mr. Ratnesh Kumar
Finance & Accounts Officer	:	Mr. Raja Ram
Assistant Administrative Officer	:	Mr. R.K. Yadav
	:	Mr. Ram Das
	:	Mr. V.P. Tiwari
	:	Mr. S.K. Bagchi
Security Officer	:	Mr. C.P. Prajapati

Joining

Scientists

- Dr. V.K. Singh joined as Sr. Scientist (Agronomy) from KVK, Koderma on April 27, 2015.
- Dr. K.K. Singh joined as Principal Scientist (Agronomy) from ICAR-IIPR, Kanpur on May 06, 2015.
- Dr. S.P. Singh joined as Senior Scientist (Plant Physiology) from ICAR-CRRI, Cuttack on June 11,2015
- Dr. D.R. Malaviya, joined as Principal Scientist from ICAR-IGFRI, Jhansi on September 01, 2015.
- Dr. Ashutosh Kumar Mall joined as Sr. Scientist (Plant Breeding) from ICAR-IGFRI, Jhansi on September 11, 2015.
- Dr. M.R. Singh, Principal Scientist (Entomology) joined as Head, Division of Crop Protection on January 07, 2016.
- Dr. Vinod Kumar Gupta joined as Principal Scientist (Plant Breeding) from NRC on Litchi, Muzaffarpur on February 03, 2016.
- Mr. Lalan Sharma, joined as Scientist (Plant Pathology) from ICAR-NBAIM, Mau on February 08, 2016.

Technical Staff

- Mr. J.P. Pandey joined as Technical Officer from ICAR Research Complex for NEH Region, RC, Gangtok on October 01, 2015.
- Mr. Deep Kumar joined as Senior Technical Assistant from Central Agricultural Research Institute, Goa, Goa on April 04, 2015.
- Sh. Atul Kumar Sachan joined as Assistant Chief Technical Officer from ICAR-IVRI, Bareilly on April 20, 2015
- Dr. Viveka Nand Singh joined as SMS, KVK Lucknow from Central Island Agricultural Research Institute Portblair on September 26, 2015
- Ms. Pallavi joined as Senior Technician from NRC on Litchi, Muzaffarpur, Bihar on October 19, 2015.
- Sh. Surendra Nath joined as Technical Officer from ICAR Research Complex for NEH Region, RC, Gangtok on September 14, 2015

Administrative Staff

- Sh. Dinesh Chand Mishra joined as LDC from ICAR-IIFSR, Modipuram on December 12, 2015
- Sh. Arjun Kumar joined as SSS from ICAR- CARI, Bareilly on April 01, 2015

Promotions

Scientists

- Dr. M. Swapna from Sr. Scientist to Pr. Scientist (Genetics) w.e.f. May 01, 2015
- Dr. Dinesh Singh from Sr. Scientist to Pr. Scientist (Plant Pathology)
- Dr. R.D. Singh from Sr. Scientist to Pr. Scientist (Farm Machinery and Power) w.e.f. January 01, 2011

Technical Staff

- Sh. Brahm Prakash from T-7-8 to T-9 w.e.f. July 1, 2017
- Mrs. Hemlata Mathok from T-7-8 to T-9 w.e.f. July 1, 2017
- Sh. Nar Singh from T-7-8 to T-9 w.e.f. July 1, 2017
- Dr. B.B. Joshi from T-7-8 to T-9 w.e.f. August 19, 2017
- Sh. Laljee Verma from T-5 to T-6 w.e.f. October 15, 2011
- Sh. S.P. Shukla from T-5 to T-6
- Sh. S.N. Srivastava from T-5 to T-6
- Sh. Dasha Ram from T-1 to T-2 w.e.f. October 17, 2015
- Sh. Suresh Chand from T-1 to T-2
- Sh. Rakesh Kumar from T-1 to T-2 w.e.f. October 13, 2015

- Sh. Shambhoo from T-1 to T-2 w.e.f. September 08, 2015
- Sh. Nand Kishore from T-1 to T-2 w.e.f. September 08, 2015

Administrative Staff

- Miss. Poonam Manish Misra from LDC to MACP
- Sh. Susheel Kumar from SSS to T-1 w.e.f. August 01, 2015
- Sh. Radhey Lal from SSS to LDC w.e.f. September 18, 2015
- Sh. Sri Ram from SSS to T-1 w.e.f. October 17,2015
- Sh. Shiv Kumar from SSS to T-1 w.e.f. October 17,2015
- Sh. Ganesh Prasad from Steno to MACP w.e.f. October 13,2015
- Sh. Pankaj Kumar from UDC to Assistant w.e.f. December 09, 2015
- Sh. Ram Sajiwan from SSS to LDC w.e.f. December 09, 2015
- Sh. S.K. Bagchi from Assistant to AAO w.e.f. December 01, 2015
- Sh. Arvind Kumar Yadav from LDC to UDC w.e.f. January 12, 2015
- Sh. Rajendra Kumar SSS to T-1 w.e.f. February 05, 2016
- Sh. Arjun from SSS to MACP w.e.f. December 06, 2015
- Sh. Chhattar Pal from SSS to MACP w.e.f. January 09, 2016
- Sh. Murni Lal from SSS to MACP w.e.f. January 31, 2016

Superannuations

Scientists

- Dr. Ramji Lal, Pr. Scientist (Plant Pathology) on February 29, 2016.
- Dr. P.K. Bajpai, Pr. Scientist (Agri. Statistics) on October 31, 2015
- Mrs. Sunita Lal, Pr. Scientist (Plant Pathology) on September 31, 2015

Technical Staff

- Sh. Lal Jee Verma, Technical Officer on May 31, 2015.
- Sh. Jhinku Ram, Technical Officer on June 30, 2015.
- Sh. Ramesh Prasad, Technical Officer on June 30, 2015.
- Sh. Amar Nath, Technical Officer on July 31, 2015
- Sh. Rajendra Singh, Technical Officer on August 31, 2015
- Sh. Shyam Lal Yadav, Technical Officer on August 31, 2015
- Sh. Arun Kumar Nath, Technical Officer on August 31, 2015
- Sh. Ram Singh, Technical Officer on September 30, 2015
- Sh. Mahendra Singh, Chief Technical Officer on September 30, 2015
- Sh. Sahab Din, Technical Officer on October 31, 2015
- Sh. R.S. Vishwakarma, Technical Officer on November 30, 2015

Administrative Staff

- Sh. Hari Shanker, SSS on April 30, 2015.
- Sh. Brij Kumar, SSS on June 30, 2015.
- Sh. Nazeer Ahmad, SSS on August 31, 2015.
- Sh. Niyaz Ahmad, SSS on August 31, 2015
- Sh. Sri Kishan, SSS on February 29, 2016

Demises

- Sh. S.K.Misra T-5 on August 21, 2015.
- Sh. Surendra Nath on February 21, 2016

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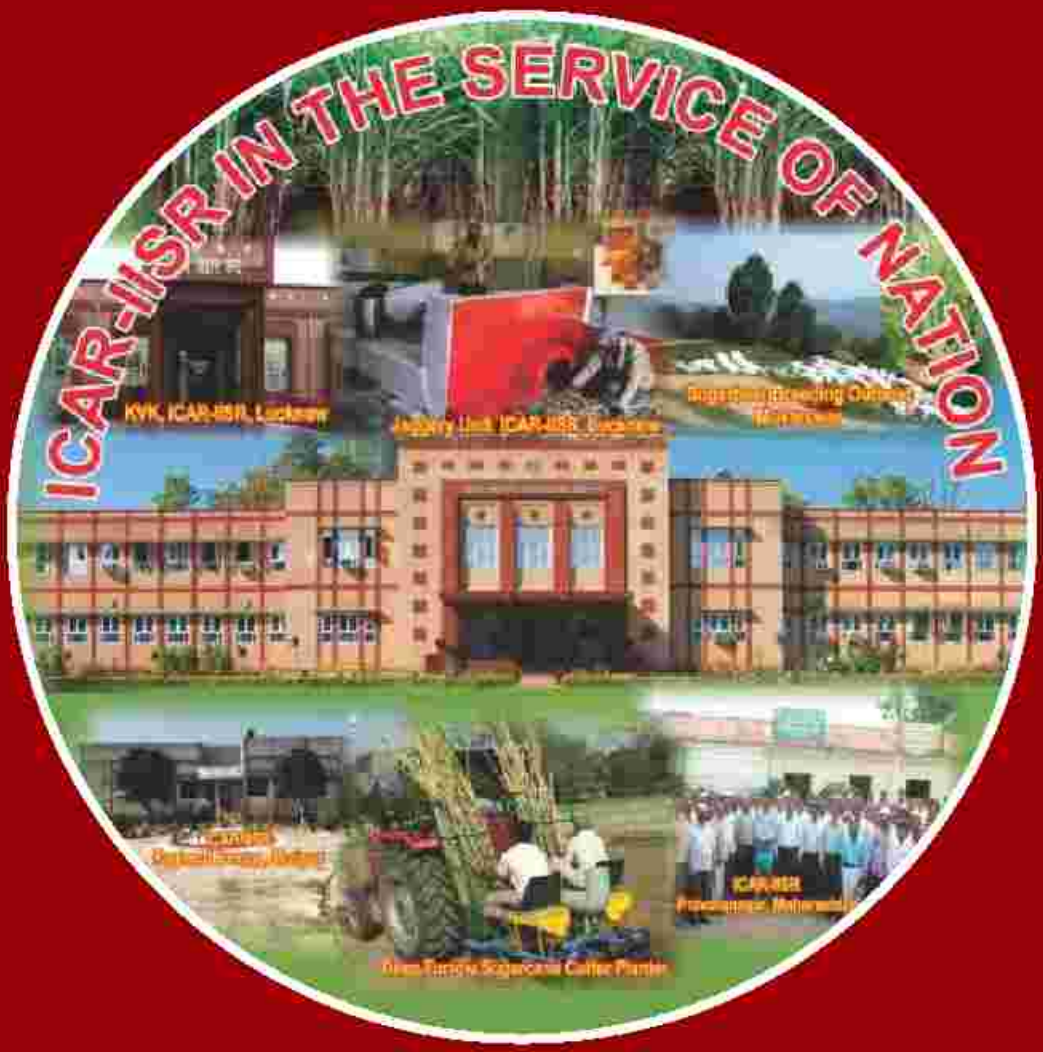
Meteorological data

Month	Temperature (°C)		RH (%)		Rainfall (mm)	Rainy days	Duration of sunshine (h/day)	Wind speed (Km/h)
	Max·	Min·	0718 Hrs	1418 Hrs.				
Apr., 2015	35.0	20.8	77	43	54.0	3	8.2	4.0
May, 2015	40.1	25.7	65	32	3.0	-	10.0	3.4
Jun., 2015	39.4	27.1	63	41	48.0	3	8.3	4.5
Jul., 2015	34.1	26.7	89	69	228.8	12	6.6	3.5
Aug., 2015	34.1	26.3	90	71	186.7	11	6.4	2.7
Sep., 2015	36.0	25.7	83	53	26.2	2	8.3	3.5
Oct., 2015	34.3	19.5	89	45	1.2	-	8.5	1.5
Nov., 2015	30.6	14.4	93	36	0.8	-	7.2	1.2
Dec., 2015	24.0	9.0	93	48	15.6	1	4.4	1.7
Jan., 2016	22.9	7.7	97	50	14.2	1	5.3	1.6
Feb., 2016	27.9	12.0	90	39	0.0	-	7.9	2.8
Mar., 2016	33.4	16.7	79	30	13.6	2	9.1	4.2
Average	32.7	19.3	84	46	-	-	7.5	2.9
Total					592.1	35		

A glimpse of event organised under

Unnat Bharat Abhiyan

(December 12-13, 2015)



भाकृअनुप–भारतीय गन्ना अनुसंधान संस्थान
लखनऊ–226 002, उत्तर प्रदेश, भारत

ICAR-Indian Institute of Sugarcane Research
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