भाकृअनुप
ICAR

भारतीय गन्ना अनुसंधान संस्थान, लखनऊ
ISO 9001 : 2008

ANNUAL REPORT
2014-15

भाकृअनुप–भारतीय गन्ना अनुसंधान संस्थान, लखनऊ
ICAR-Indian Institute of Sugarcane Research, Lucknow

भाकृअनुप
ICAR

वार्षिक प्रतिवेदन
Annual Report

2014-15

भारतीय गन्ना अनुसंधान संस्थान, लखनऊ
ISO 9001 : 2008

भाकृअनुप–भारतीय गन्ना अनुसंधान संस्थान
लखनऊ–226 002, उत्तर प्रदेश, भारत
ICAR-Indian Institute of Sugarcane Research
Lucknow - 226 002, Uttar Pradesh, India

Published by:

Dr. O.K. Sinha
Director
ICAR-Indian Institute of Sugarcane Research,
Raebareli Road, P.O. Dilkusha, Lucknow 226 002, U.P.

Compiled and edited by:

Dr. J. Singh, Principal Scientist
Dr. Sanjeev Kumar, Senior Scientist
Shri Brahm Prakash, ACTO

Correct citation:

Annual Report 2014-15
ICAR-Indian Institute of Sugarcane Research, Lucknow

Cover photo:

Demonstration of Deep Furrow Sugarcane Planter during 'Technology and Machinery Demonstration Mela', organised at IISR, Lucknow on March 20, 2015.

Printed at: Maheshwari and Sons, 289/214, Moti Nagar Chauraha, Lucknow 226004

Preface

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. Even though sugarcane remains the major source of sugar in the country, there has been a paradigm shift with the crop being recognized as an important feed stock for second generation (2G) ethanol production using bagasse and other cellulosic material like trash. From the present average cane productivity of about 71 t/ha and 10.23% sugar recovery, we have a greater challenge to attain an average cane productivity of >100 t/ha with a recovery of 11% by 2030 so as to fulfil the requirement of burgeoning population. Moreover, to promote bioethanol production from bagasse, technologies have to be designed accordingly.

The situation demands concerted efforts, with an effective integration of sugarcane improvement, production, protection and other management techniques including mechanization, to improve the production and productivity levels. With not much scope for an increase in area under the crop, our future strategy should be on the vertical increase of cane productivity along with sugar content. The National Policy on Biofuels of the Government of India has proposed a target for 20% blending of ethanol in the automobile fuel by 2017. This future demand for ethanol would necessitate tailoring varieties with increase in fibre content and biomass. The daunting task of combining both high fibre and high sugar in the varieties is not very easy and needs to be brought about through a balance of both fibre and sugar content. In addition, technology for deriving ethanol from bagasse and other cellulosic material through enzymatic and microbial fermentation process, needs commercialization.

Enhancement in cane productivity and sugar content will necessitate development of improved varieties, improved planting methods and planting material, water-use efficient irrigation practices, soil health enhancement measures, improved land-use efficient strategies, refinement in machinery, physiological and nutrient efficient varieties, crop protection technologies for location-specific diseases and insect pests including bio-control strategies.

The varieties developed recently through NARS have shown high productivity with increase in sugar recovery. Varieties like CoLk 94184, Co 0238, Co 0118, Co 05011, CoPK 05191, CoH 128, etc., have shown great promise in enhancing both cane productivity and sugar recovery in sub-tropical India. Such varieties with the support of suitable machines for sugarcane cultivation have shown enhanced cane yield up to 110 t/ha in some of the cane growing regions of Uttar Pradesh and up to 80 t/ha in Bihar. Extensive seed production of improved varieties taken up by the Institute in Bihar under the sponsorship of Govt. of Bihar has shown encouraging results in enhancing cane productivity and sugar recovery.

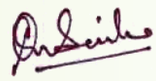
Any technology developed by the researchers should be demonstrated at the farmers' field for further refinement and improvement and for convincing the growers for adoption. In this context, the Institute has conducted demonstration of several technologies at farmers' field during the year 2014-15. Overwhelming response was received from farmers and their families during the "Mechanization Day" organized at the Institute on 20th March 2015. The farmers were highly impressed by the machinery and other technologies developed.

The Institute has laid major emphasis on development of low-cost technologies. Efforts have been made to reduce the cost of seed as well as crop management practices, making use of improved planting methods and planting machines, water saving technology, plant protection measures intensifying bio-control and eco-friendly measures, healthy seed production, etc. Recently, the Plant Tissue Culture Laboratory of the Institute has been accredited by the Department of Biotechnology under the National Certification System for Tissue Culture Raised Plantlets. It will be a facility for disease indexing and testing genetic fidelity of sugarcane and other crops. The Institute is also engaged in value-addition and diversification of sugarcane. Value-added jaggery with fortification of Vitamin C using *Aonla* as a source, and vinegar have been

developed. Biofertilizer production and on demand distribution has shown encouraging results. To intensify biocontrol of major insect pests, trichocards have been distributed in many farmer fields.

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. We hope that the technologies developed would help the farmers as well as industry and the Institute will continue to serve the stakeholders.

We gratefully acknowledge the unstinted support and guidance from Dr. S. Ayyappan, Secretary (DARE) and Director General, ICAR; Dr. J. S. Sandhu, Deputy Director General (CS); Dr. N. Gopalakrishnan, former ADG (CC); Research Advisory Committee members, sugar industry representatives and sugarcane growers at appropriate junctures. We are thankful to Heads of Divisions, Incharge, Sections, PC (Sugarcane), scientists, technical and administrative staff for providing information for Annual Report. The efforts of Dr. J. Singh, Principal Scientist & Chairman, Dr. Sanjeev Kumar, Senior Scientist and Shri Brahm Prakash, ACTO, members of Editorial Committee in compiling and editing the report for timely publication are highly appreciated. I also thank Dr. M. Swapna, Principal Scientist, for her help in various ways.



(O.K.Sinha)

Director

Contents

Executive Summary

- Two sugarcane clones in early maturing group (CoLk 14201 and CoLk 14202) and three in midlate maturing group (CoLk 14203, CoLk 14204 and CoLk 14205) were accepted for multi-location testing under North West Zone of AICRP (Sugarcane). The clone CoLk 14201 was also accepted for testing under State Varietal Trial (SVT) in Uttar Pradesh.
- Five elite clones, viz., CoLk 14206, CoLk 14207, CoLk 14208, CoLk 14209 and CoLk 14210 proposed from IISR-Regional Centre, Motipur (Bihar) were accepted for multi-location evaluation in the North Central and North Eastern Zone of AICRP on Sugarcane.
- Sixteen clones, viz., LG 10801, LG 10801A, LG 10803, LG 10805, LG 10808, LG 10814, LG 10815, LG 10816, LG 10817, LG 10818, LG 10823, LG 10824, LG 10827, LG 10828, LG 10830 and LG 10833 were found promising for cane and sugar yield, as well as resistance to two pathotypes (CF 08 and CF 09) of red rot pathogen.
- A multiplex PCR-based diagnostic tool that included three primer pairs designed from the conserved region of r-DNA was developed for red rot, smut and sugarcane grassy shoot diseases which can be detected simultaneously.
- In marker-trait association study for yield and related traits, significant associations were identified for four markers with cane diameter, seven markers each with cane length and number of millable canes, eleven markers with number of nodes, six with sucrose per cent, and five markers with average cane weight. These could be exploited for marker-assisted breeding programme.
- More than 20000 plantlets of released varieties of sugarcane, viz., CoLk 9709 and Co 05011 were multiplied through micropropagation and trans-planted in field for production of breeder seed.
- A total of 6000 q seed cane of 10 improved varieties of sugarcane was produced, out of which 5200 q seed cane was lifted and the rest was utilized for further multiplication. More than 10.0 ha area was planted with newly released varieties. Breeder seed production of new varieties was undertaken in 17.0 ha in Muzaffarnagar district.
- Under the Bihar Government sponsored project, 21160 q breeder seed of six varieties was produced at Motipur, Harinagar and Hasanpur and distributed to nine sugar factories in Bihar.
- Research on acceleration of sugarcane emergence through priming of cane nodes revealed that priming with mixture of cattle dung, cattle urine and water in 1:2:5 ratio and planted directly in the field or after incubation (4 d) gave a significantly higher germination (70.47%) at 45 DAP compared to un-primed cane nodes (53.64%). The primed cane nodes registered 13.4% higher cane yield over un-primed cane nodes.
- Studies on productivity of sugarcane under wheat-sugarcane cropping system evinced that wheat sown in the month of November + sugarcane planted in February under FIRB method produced significantly higher cane equivalent yield (96.5 t/ha) over sugarcane planted in October + wheat in November at 1:3 row ratio (77.8 t/ha).
- Application of $ZnSO_4$ (15 kg/ha) along with P_2O_5 (60 kg/ha) recorded the highest cane yield (80.5 t/ha). No further enhancement was recorded with further increase in $ZnSO_4$ and P_2O_5 levels to 30 and 60 kg/ha, respectively. Interaction effect of phosphorus and zinc on cane yield was non-significant.
- Optimization of irrigation application parameters, *viz*., furrow length, water discharge rate and cut off length for furrow irrigation in sugarcane showed that significantly higher shoot count (157.9 k/ha at 150 DAP), NMC (111.8 k/ha), cane yield (62.8 t/ha) and sugar yield (8.8 t/ha) were recorded with the discharge of 10 litres per second (Lps) + 85% cut off length. This combination also resulted in higher irrigation water use efficiency (IWUE) of 2064.9 and 2414.5 kg/ha-cm in 50 m and 75 m furrow lengths, respectively.
- The sub-surface drip irrigation significantly increased NMC, cane length and cane yield in second ratoon crop; the highest cane yield of 103.0 t/ha was recorded under recommended dose of nitrogen and water equivalence of 125% pan evaporation (PE). Irrigation water use efficiency was the highest (2554.7 kg/ha-cm) under fertigation and maintaining amount of irrigation water at 75% PE.
- Sugarcane ratoon yielded significantly higher (83.6 t/ha) when sugarcane was planted by placing three setts at intra-row spacing of 30 cm (end-to-end) as compared to conventional planting (74.1 t/ha).
- Soil organic carbon was improved (0.58% at 0-15 cm depth) under sugarcane-based cropping system (sugarcane-ratoon-wheat) compared to rice-wheat-rice-wheat (0.45%). A similar trend was also observed at 15-30 cm depth.
- Use of plant growth regulator GA_3 right from planting stage to every critical growth stages led to a higher plant population density and physiological efficiency in the variety CoLk 94184. These culminated to T_{max} 11.6 lakh shoots/ha as against 3.83 lakh shoots/ha in control at 180 DAP. Later, tiller survival of about 62% culminated in 4.43 lakh/ha NMC with cane yield of 330.0 t/ha as against tiller survival of about 61% resulting in 1.52 lakh/ha NMC with cane yield of 129.0 t/ha in control.

- In late-planted crop (CoLk 94184), the hormonal interventions manifested in 94 k/ha NMC with cane yield of 76.0 t/ha as against 65 k/ha NMC with cane yield of 39.7 t/ha in control.
- Overnight-primed 3-bud setts (CoLk 94184) with ethrel treatment planted in spring season showed improved (46%) germination over control (22%) at 45 DAP. Germination in water-primed setts was only 29%. When whole cane was planted having similar level of treatments, germination was 58% (ethrel), 38% (water), and 17% (control).
- Survey was conducted for insect-pests and diseases in the command area of various sugar mills of U.P., Bihar, Maharashtra and Chhattisgarh. Incidence of red rot, smut, Pokkah Boeng and grassy shoot disease was observed in different areas. In Kawardha area (Chhattisgarh), sugarcane fields were severely infested with *Pyrilla purpusilla*. Egg parasite, *Tetrastichus pyrillae* was also observed.
- This year, 211 genotypes were screened against red rot (CF 08 and CF 09) and smut. 139 genotypes were moderately resistant (MR) to red rot, 162 were tolerant to smut and 145 showed field tolerance against wilt.
- The highest inhibition (76%) of *C. falcatum* growth *in vitro* was observed when treated with *Trichoderma* culture filtrate of isolate STr-121. In field experiment, the highest reduction (55.1%) in bud mortality was observed in treatment with culture filtrate of isolate STr-108.
- Tractor operated PTO driven deep furrow sugarcane planter was designed and developed. It performs all the unit operations involved in sugarcane planting, *viz.*, furrow opening, sett cutting, sett placement in furrows, fertilizer and insecticide application(s), soil covering over setts and its tamping, simultaneously in a single pass of the planter. It creates loose soil bed underneath the planted setts.
- The power transmission and fertilizer metering units of IISR paired-row sugarcane trench planter were redesigned and modified. Prototype of sugarcane trench planter was developed and showed an effective field capacity of 0.2 ha/h at IISR farm.
- Prototype of tractor operated sugarcane manager with seed drill attachment was developed. It performs inter-culture and fertilizer application in standing cane crop, and also facilitates sowing of intercrop in sugarcane ratoon field. The prototype was tested in the field and showed an effective field capacity of 0.4 ha/h.
- A cleaning-cum-washing machine for surface cleaning of cane stalks was developed.
- Training and extension programme were organised for District cane officers, cane development staff of sugar mills and state cane department, and cane growers. Information in latest sugarcane cultivation techniques was disseminated through electronic and print media.

About the Institute

The 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 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 36^0C to 40^0C and minimum temperature during November to February ranges from 7^0C to 11.5^0C. 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

The mandate of the Institute as approved by the ICAR is as follows:

i) To conduct basic and applied research on all aspects of production and protection techniques of sugarcane and other sugar crops for different agro-climatic zones of the country

ii) To work on the breeding of varieties for sub-tropical region in close collaboration with Sugarcane Breeding Institute, Coimbatore

iii) To carry out research for diversification and value-addition in sugarcane

iv) To develop linkages with State Agricultural Universities, Research Centres and other organizations for collaborative research, exchange of information and material, and

v) To provide training, and consultancy to end users at regional, national and international levels.

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

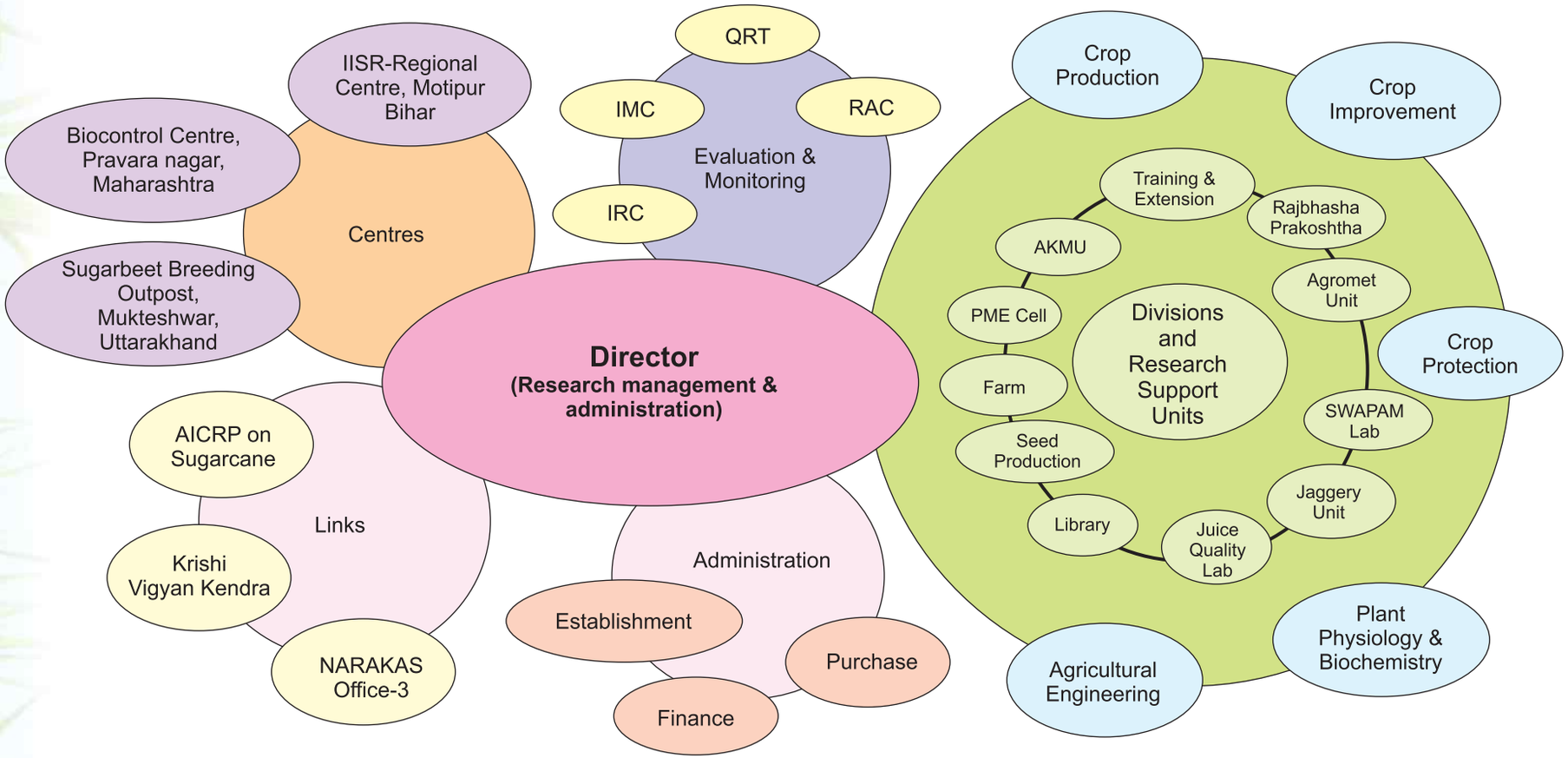
e. Mechanizing sugarcane farming

Arresting decline in factor productivity

a. Soil biological and nutritional dynamism

b. Carbon sequestering through cropping system

Indian Institute of Sugarcane Research, Lucknow



Organizational Structure

Budget: 2014-2015

Particulars	Non-Plan (₹ lakh)		Plan (₹ lakh)	
	Revised Estimate	Expenditure	Revised Estimate	Expenditure
Indian Institute of Sugarcane Research	3497.50	3435.84	469.00	464.94
AICRP (S)			884.00	883.97

Staff position as on March 31, 2015

Category	Sanctioned	Filled	Vacant
Scientific (including RMP)	74	54	20
Technical	129	119	10
Administrative	48	46	02
Supporting	74	51	23
Total	**325**	**270**	**55**

1

Genetic improvement of sugarcane for higher cane and sugar productivity

Sugarcane clones accepted for evaluation under AICRP on Sugarcane

Four sugarcane clones in early maturing group (CoLk 14201, CoLk 14202, CoLk 14206 and CoLk 14207), and six mid-late maturing sugarcane genotypes (CoLk 14203, CoLk 14204, CoLk 14205, CoLk 14208, CoLk 14209 and CoLk 14210) were accepted for multi-location testing in North West Zone during AICRP (Sugarcane) Group Meeting held at Indian Institute of Sugarcane Research, Lucknow on Nov. 1-2, 2014. The salient agronomic features of accepted entries are given in Table 1.1.

Table 1.1. Sugarcane clones accepted for evaluation under AICRP on Sugarcane

Genotype (Selection No.)	Parentage	Zone	CCS (t/ha)	Cane yield (t/ha)	Sucrose %
Early Group					
CoLk 14201 (LG 09062)	Co 0238GC	NW	11.5	92.5	18.2
CoLk 14202 (LG 07444)	CoS 96268GC	NW	12.5	104.6	17.6
CoLk 14206 (MG 10036)	LG 97050 × CoSe 92423	NC & NE	10.8	88.3	17.6
CoLk 14207 (MG 10009)	LG 97050 × CoSe 92423	NC & NE	10.6	90.3	16.9
Mid Late Group					
CoLk 14203 (LG 09072)	CoLk 8002 × CoSe 92423	NW	14.3	105.1	19.5
CoLk 14204 (LG 09067)	CoLk 8002 × CoSe 92423	NW	13.1	108.6	17.4
CoLk 14205 (LG 07652)	28NG20(50) × IK 76-99	NW	12.7	104.6	17.4
CoLk 14208 (MG 10018)	LG 97050 × CoSe 92423	NC & NE	11.8	98.5	17.2
CoLk 14209 (MG 10038)	LG 97050 × CoSe 92423	NC & NE	11.5	95.6	17.4
CoLk 14210 (MG 10144)	LG 97050 × CoSe 92423	NC & NE	10.9	92.4	16.9

Evaluation of sugarcane genotypes under station trial

Twenty sugarcane clones emanating from different breeding projects of the Division were evaluated with four check varieties. The clones exhibited significant differences for yield and quality attributes. The highest CCS (commercial cane sugar) yield was recorded for clone LG 07584, followed by LG 09120, LG 09760, LG 09746, LG 08420 and LG 09743. The highest sucrose content was recorded in LG 08420 followed by clone LG 09746 and LG 09039 over best check (CoJ 64) for sucrose at 10 month. However, at 12 month, LG 09743 had the highest sucrose content followed by LG 09746, LG 08420 and LG 09039. The highest cane yield was recorded in LG 07584, followed by LG 09120, LG 09760 and LG 09746 (Table 1.2).

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

The collection of 314 genotypes consisting of *Saccharum officinarum*, *S. barberi*, *S. sinense*, ISH clones, IkshuISH clones, LG selections, commercial hybrids, etc., was maintained and the seed material 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. Twenty-five new genotypes, including somaclonal variants and high sugar parental stocks, screened under other Divisional projects and found promising were added to the collection. The data obtained from Varietal Cafeteria planted during October, 2013 indicated a wide variability among recommended varieties of Uttar Pradesh for fibre% in cane, sucrose % in juice, single cane weight, number of millable canes, etc. This

Table 1.2. Performance of sugarcane clones for yield and quality in the Station Trial 2014-15

Genotype	CCS (t/ha)	Cane yield (t/ha)	Sucrose % (8 M)	Sucrose % (10 M)	Sucrose % (12 M)
LG 07642	6.1	48.7	14.0	16.1	16.6
LG 07645	11.8	83.3	16.1	17.5	18.2
LG 07680	5.9	45.3	14.5	15.7	17.4
LG 07461	11.8	84.3	16.9	17.5	18.2
LG 07554	8.7	61.7	16.4	17.8	18.2
LG 08425	9.1	65.7	16.6	17.8	17.7
LG 07470	7.6	58.0	15.2	16.4	17.1
LG 08420	12.5	77.0	17.8	18.7	18.8
LG 07584	15.0	110.7	16.7	17.3	17.9
LG 09075	10.7	78.0	15.2	17.8	18.4
LG 09039	10.6	76.0	16.7	18.2	18.7
LG 07096	7.8	62.0	15.4	16.6	17.3
LG 10035	10.7	85.3	15.6	16.6	17.4
LG 09120	13.5	96.7	16.0	17.8	18.4
LG 08826	5.6	47.7	15.0	15.7	16.3
LG 08869	11.4	79.0	15.3	17.7	18.4
LG 09707	10.7	74.3	16.0	17.6	17.8
LG 09746	12.5	89.7	16.6	18.4	18.8
LG 09743	12.0	84.7	16.4	18.0	19.0
LG 09760	12.6	96.7	16.1	17.2	17.6
CoS 767	9.9	75.7	15.2	16.7	17.8
CoPant 97222	9.1	70.3	15.2	17.0	17.6
Co 0238	9.8	72.3	16.7	18.1	18.6
CoJ 64	8.2	58.3	16.9	18.1	19.1
CD (5%)	1.9	13.7	0.9	0.7	0.7
CV (%)	11.6	11.1	3.4	2.4	2.3

variability can help farmers to opt for the most suitable variety for specific conditions prevailing in their area and even farms. A 'Varietal Cafeteria' comprising of 10 early and 13 mid-late maturing varieties of Uttar Pradesh was again planted in October, 2014 to provide an opportunity for farmers to select varieties of their choice.

Developing breeding stock for high sugar in sugarcane

This project is in its concluding phase and aimed at the development of high sugar breeding stocks to be used for conferring early sugar accumulation potential to the progeny with a high probability. Till date, over 60 high sugar selections have been sent to the National Hybridization Garden, SBI, Coimbatore and are being studied and utilized for their breeding value for high sugar content.

Effecting crosses at Sugarcane Breeding Institute, Coimbatore: A total of 27 crosses were made among the LG parental clones during the 2014 crossing season. These included 1 bi-parental cross, 5 selfs and 21 general collections.

Seedling raising and transfer: Over 2330 seedlings were raised from the fluff of 2013 matings largely among the LG clones and transferred to the field for evaluation.

Selection in the ratoon of C_0 seedlings: Sixty-four selections were made in the ratoon of C_0 seedlings based on early brix and visual observation. Notable crosses were LG 99164 GC, LG 01118 GC and LG 05434 GC, giving a relatively high proportion of desirable segregants. There were a few more but the number of seedlings evaluated was small.

Selection in C_1 population: From the C_1 population, two separate un-replicated trials comprising of 75 and 64 selections, respectively were planted from the plant crop (LG 2013 series) and the ratoon crop (LG 2012 series). These selections, advanced to C_2 were based on cane morphology and early brix.

Selection in C_2 preliminary evaluation trial: A replicated trial was laid out with 29 elite clones selected on the basis of performance in the plant and ratoon crops of the preliminary evaluation trials.

Inclusion of entries in the Station Trial: Six elite clones with resistance to red rot were earmarked in the plant and ratoon crops of the AVT trials for inclusion in the Station Trial (2015-16) of the Division. These varietal clones were LG 07436, LG 07454, LG 08443, LG 09460, LG 09487 and LG 10435 and were predominantly the progeny of LG breeding stocks developed under this project. Apart from this, there was a heavy infestation of stalk borer, adversely affecting the sugar content of the canes. Observations were recorded on the stalk and internode borer incidence in various genotypes in the AVT (P).

Proposal in AICRP (S): The clone LG 07444 accepted for AICRP (S) testing in the North Western Zone as early maturing variety, designated as CoLk 14202.

Ear-marking high sugar selections: Seven high sugar selections, comparing favourably with high sugar check CoJ 64, have been ear-marked for further confirmation. These were LG 09459, LG 09475, LG 07590, LG 08413, LG 07507, LG 08420 and LG 09460. Till date, under this project, 60 breeding stock have been sent to National Hybridization Garden (NHG), Sugarcane Breeding Institute, Coimbatore.

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

Hybridization program: Seven crosses, comprising of two bi-parental crosses, *viz*., BO 91 × ISH 150 and Co 62198 × ISH 150, three (LG 05828, LG 06810 (CoLk 12205) and CoLk 9412) selfs and two general crosses of Co 1148 and CoLk 8002, were attempted at the NHG, SBI, Coimbatore .

Evaluation of progenies of seedling generation: A total of 1242 seedling progenies of nine crosses, *viz*., one self of Co 1148 (315 seedlings), four bi parental crosses CoLk 8102 × LG 94164 (105), Co 7314 × Co 1148 (18), Co 62198 × ISH 147 (105), ISH 287 × Co 8353 (96) and four general crosses of BO 91 (120) and CoLk 8102 (84), CoLk 8002 (63) and Co 1148 (336) were transplanted and evaluated for their individual performance. Observations on the number of tillers and shoots per clump, visual performance (score; very good =1, good = 3, poor = 5 and very poor = 7) and growth were recorded and clumps were rejected on the basis of poor vigour and defects in agronomic characters. These seedlings were ratooned for further evaluation.

Evaluation and selection of clones from seedling ratoon crop: A total of 174 progenies from thirteen crosses, viz., Co 0238 × CoSe 92423 (12 selections), CoH 10291 × CoPant 97222 (3 selections), CoS 8436 × CoS 96260 (4), Co 98010 × Co 775 (4), CoLk 8102 × CoH 15 (1), CoLk 8102 × BO 91 (13), BO 91 × CoS 90263 (8), Co 86002 × CoJ 61 (3), BO 91 × Co 62198 (51), CoV 89101 PC (33), MS 6847 × CoV 92102 (4), Co 98008 × ISH 147 (14) and Co 98008 × Co 775 (24) were promoted to the first clonal generation to test these clones for red rot reaction based on the performance of individual clump in plant as well as ratoon crop. The highest range for the traits, *viz*., number of shoots/clump (4-10), millable canes/clump (2-8) and HR brix (13.6-21.4%) was recorded in the progenies of Co 86002 × ISH 147 while, variability for NMC (2-9) and for HR Brix (18.6-22.53%) was recorded in the progenies of BO 91 × Co 62198. Three crosses, *viz*., CoS 8436 × CoS 96260, Co 98010 × Co 775 and MS 6847 × CoV 92102 did not show better ratoonability.

Evaluation and selection of resistant clones to red rot in first and second clonal generation: A total of 85 clones from fourteen crosses, *viz*., BO 91 × LG 97050 (9 selections), CoS 767 × ISH 150 (6), CoS 8436 × ISH 147 (9), Co 1148 × ISH 150 (5), Co 1148 × BO 91 (10), ISH 100 × CoSe 92423 (24), Co 1148 GC (6), LG 05828 GC (5), LG 05817 GC (4), CoLk 8002 GC (1), ISH 11 GC (3), BO 91 GC (2) and self of ISH 150 (1) were selected, based on agronomic characters, reaction to red rot pathotype CF 08 and HR Brix %. These clones exhibited moderately resistant (46), and moderately susceptible (39) reaction to red rot pathotype CF 08.

In the second clonal generation, out of 43 progenies, 13 clone, *viz*., LG 11802, LG 11804, LG 11805, LG 11806, LG 11811, LG 11805 and LG 11815 (BO 91 × Co 62198), LG 11817 (CoSe 95422 × Co 05828), LG 11821 and LG 11822 (Co 1148 × BO 91), LG 11832, LG 11837 and LG 11843 (LG 05828 self) exhibited moderately resistant reaction to red rot pathotypes CF 08 and CF 09. All the five clones had >17% sucrose with

good phenotypic performance and were advanced for further evaluation.

Sixteen clones, *viz*., LG 10801, LG 10801A, LG 10803, LG 10805, LG 10808, LG 10814, LG 10815, LG 10816, LG 10817, LG 10818, LG 10823, LG 10824, LG 10827, LG 10828, LG 10830 and LG 10833 in C_3 generation exhibited moderately resistant reaction to red rot pathotypes, CF 08 and CF 09.

Clonal evaluation: A total of 537 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. Among them, 42 were advanced for further evaluation. Out of 47 C_1 clones evaluated, 13 were advanced to C_2 stage, and included for red rot evaluation. Out of 62 C_2 clones evaluated, 25 were advanced to C_3 stage. The yield of 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.

Table 1.3. Performance of advance clones of sugarcane for yield and quality traits in plant crop during 2014-15

Clone	Parentage	NMC (k/ha)	Yield (t/ha)	Sucrose (%)	CCS (t/ha)	SCW (kg)	Red rot reaction	
							CF 08	CF 09
LG 10801	BO 91 × Co 62198	126.1	85.8	18.33	10.9	0.68	MS	MS
LG 10803	BO 91 × Co 62198	101.8	66.6	17.63	7.9	0.65	MR	MR
LG 10812	BO 91 × Co 62198	101.2	66.2	17.83	8.0	0.65	MS	MS
LG 08869	CoPant 97222 GC	120.8	73.3	17.63	9.0	0.61	MR	MR
LG 10817	CoS 96268 × BO 91	104.2	58.8	17.43	7.1	0.56	MR	MR
LG 09810	BO 91 GC	112.5	64.5	17.80	8.0	0.57	MR	MR
LG 09814	CoLk 8002 × Co 62198	132.0	84.1	17.90	10.6	0.64	MS	MS
CoJ 64		107.7	46.9	18.98	6.2	0.47	S	S
CoS 767		100.6	47.4	18.65	6.2	0.49	S	S
CD (5%)		10.5	9.10	0.75	1.1	0.06		
CV (%)		5.73	8.56	2.49	8.5	5.73		

Evaluation of advance clones in ratoon: This trial consisted of 14 advance clones that were evaluated along with two checks, *viz*., CoJ 64 and CoS 767 in CRBD with three replications to assess their yield and quality performance. Clones, LG 10801, LG 10807, LG 10812, LG 10815, LG 10817, LG 09810, LG 09814, LG 08826 and LG 08869 showed moderate resistance (MR) to both the virulent pathotypes, *viz*., CF 08 and CF 09. LG 10801 showed the highest cane yield (85.8 t/ha), followed by LG 09814 (84.9 t/ha), LG 08869 (73.3 t/ha), LG 10803 (66.6 t/ha) and LG 10812 (66.2 t/ha) over the best check CoS 767 (47.4 t/ha). These four clones recorded >17.7% sucrose. A similar trend was recorded in ratoon crop with relatively low cane yield. However, LG 09810 (59.3 t/ha) and LG 09814 (61.7 t/ha) were found to be good ratooner. Three clones, viz., LG 08869, LG 09810 and LG 09814 exhibited moderate resistance to red rot for two virulent pathotypes, CF 08 and CF 09 for the last three years.

Development of top borer tolerant genetic stocks of sugarcane

Hybridization: Two intergeneric crosses, involving *Erianthus* spp. as one of the parents, *viz*., Awela-68 × IK 76-91 and LG 94184 × IK 76-81 and three general collections and one self of an intergeneric hybrid were made. A total of 904 seedlings from different crosses were transplanted in the field for evaluation.

Genotypes 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 the Station Trial. The detail features of genotypes are embodied in Table 1.4.

Development of sugarcane varieties for subtropics

Hybridization and sowing of fluff: A total of 12 bi-parental crosses were made under zonal crosses of AICRP (S), 9 poly-crosses and 30 general crosses were also received for evaluation. Fluff was sown in glass-house during March 2015. In general, germination was poor in the bi-parental crosses, but GCs showed fairly good germination. Fluff will be sown in batches in order to obtain more number of seedlings.

Evaluation of sugarcane crosses: A total of 9924 seedlings from 55 crosses, including bi-parental, zonal crosses, poly-crosses and GCs from 2013 crossing season were transplanted in the field during July 2014. Seedlings were ratooned in March 2015, which will be evaluated during November 2015. A total of 183 clones from 24 crosses were selected and planted for multiplication and evaluation.

Table 1.4. Features of genotypes advanced to station trial

Genotype	Parentage	Cane yield (t/ha)	Sucrose (%)	Cumulative top borer incidence (%)
LG 11632	LG 04601 GC	92.2	19.84	2.86
LG 11645	BO 91 × CoLk 8102	94.6	17.06	4.67
LG 11650	BO 91 × CoLk 8102	102.0	16.65	5.00
LG 11663	Co 1158 × CoLk 8002	88.7	17.00	3.39
CoJ 64		55.6	17.54	14.60
CoPant 97222		58.3	17.49	12.20
CoS 767		60.5	17.87	10.27
Co 0238		72.2	18.02	28.67
CD (5%)		6.9	2.37	-
CV (%)		12.7	8.72	-

Evaluation of C_2 clones: A total of 110 sugarcane clones was planted for evaluation along with the standards. Observations were made on vigour, growth and HR Brix %. The crop was severely affected by *Pyrilla*. Twenty seven clones were selected for further evaluation.

Evaluation of advance clones: Thirty eight advance clones were evaluated along with the standards, CoJ 64 and CoS 767. The clones were also evaluated for red rot reaction. Data were recorded for quality parameters and fibre content. On the basis of red rot reaction, quality and visual observations, eight clones were advanced for initial yield evaluation in large plot replicated trials (Table 1.5).

efficient of 0.81. The clone LG 09119 was found to be the most diverse.

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

Clonal evaluation: A total of 37 sugarcane selections at different clonal stages were evaluated for their growth performance and quality parameters. Out of these, ten clones such as MG 10007, MG 12001, MG 10117, MG 12034, MG 10143, MG 10090, MG 10138, MG 10098, MG 12010 and MG 10053 were found to be promising as these clones had shown sucrose content at par with CoSe 95422.

Table 1.5. Performance of selected advanced sugarcane clones

Clone	Yield (t/ha)	Cane weight (kg)	Sucrose (%)		Fibre (%)	Red rot reaction	
			(Dec.)	(Feb.)		CF 08	CF 09
LG 09019	83.4	0.7	15.35	17.16	13.15	MR	MR
LG 09119	89.0	0.8	15.36	16.12	14.72	MR	MR
LG 09120	107.0	0.9	17.39	18.38	16.19	MR	MR
LG 10006	78.6	0.6	15.79	18.01	15.64	MR	MR
LG 11001	112.5	1.1	15.31	17.81	12.50	MR	MR
LG 11158	89.0	1.0	15.48	16.68	13.47	MR	MR
LG 11166	76.0	0.7	16.36	17.05	11.65	MR	MR
LG 11167	87.0	0.7	17.23	17.40	14.92	MR	MR
CoJ 64	64.5	0.9	17.62	18.60	13.3	HS	S
CoS 767	73.5	0.8	16.13	17.60	14.7	MR	MS

Evaluation of elite clones based on genetic diversity: A preliminary evaluation of the genetic diversity among a group of 15 elite clones of sugarcane from B1.13 project along with the check varieties, *viz.*, CoJ 64 and Co 0238 was carried out using 20 highly polymorphic EST-SSR markers. The genotypes showed a moderate level of genetic diversity with an average Jaccard's Co-efficient value of 0.58. The clone, CoLk 14201, was found to be highly similar to its female parent Co 0238 with Jaccard's similarity Co-

Hybridization and seedling raising: Fifteen bi-parental crosses were attempted at the National Hybridization Garden, Sugarcane Breeding Institute, Coimbatore during the 2014 crossing season. In addition, sixteen Zonal Crosses for North Central Zone and eight Poly-crosses for subtropical India were also attempted during the season. Fluff of all the Station Crosses, Zonal Crosses, Polycrosses and 25 GCs was received and shall be sown to the seedlings for progeny evaluation.

Evaluation of early maturing sugarcane clones for North West Zone

Initial Varietal Trial (Early): Seven genotypes, *viz.,* CoLk 11201, CoLk 11202, CoLk 11203, CoH 11261, CoH 11262, CoPb 11211 and CoPb 11212 along with two standards Co 0238 and CoJ 64 were evaluated for yield and quality parameters. The genotype CoH 11261 recorded the highest cane yield (79.8 t/ha), followed by CoLk 11203 (67.7 t/ha) and CoLk 11202 (59.3 t/ha). The genotype CoLk 11203 showed the highest CCS yield (8.6 t/ha) followed by CoH 11261 (7.4 t/ha) and CoLk 11201 (7.3 t/ha). Among the test genotypes, CoLk 11201 and CoLk 11203 recorded the highest sucrose percentage at harvest (18.3%) followed by CoLk 11202 (17.2%) and CoH 11262 (16.5%). Among the standard varieties, Co 0238 recorded the highest CCS yield (7.1 t/ha), followed by CoJ 64.

Advanced Varietal Trial (Early) I Plant: A trial comprising of three genotypes, *viz.,* Co 10035, CoH 10261 and CoS 10231, along with two standard varieties CoJ 64 and CoPant 84211, was conducted. The genotype CoH 10261 recorded the highest cane yield (66.7 t/ha) which was significantly superior to the best check, CoJ 64. CoS 10231 exhibited the highest sucrose % at 10 months (17.5%), followed by CoH 10261(17.4%) and Co 10035 (17.2%). Among the standard varieties, CoJ 64 was found to be the best for both cane yield (60.6 t/ha) and CCS yield (7.7 t/ha).

Advanced Varietal Trial (Early) II Plant: A trial comprising of five test genotypes, *viz.,* CoLk 09202, CoH 09262, CoH 09263, CoPb 09181and CoS 09246, along with two standard varieties, *viz.,* CoJ 64 and CoPant 84211 was conducted. Genotype, CoLk 09202 recorded the highest cane yield (85.3 t/ha), followed by CoPb 09181 (72.0 t/ha) and CoS 09246 (53.7 t/ha). The highest sugar yield was observed in CoLk 09202 (9.67), followed by CoPb 09181 (6.3 t/ha) and CoS 09246 (6.2 t/ha). The genotype, CoH 09262 showed the highest sucrose percentage at harvest (17.61%), followed by CoS 09246 (16.95%) and CoLk 09202 (16.24%). Among the standards, CoJ 64 was the best check for cane yield (55.3 t/ha) and CCS yield (6.9 t/ha).

Advanced Varietal Trial (Early) Ratoon: Five genotypes, *viz.,* CoLk 09202, CoH 09262, CoH 09263, CoPb 09181and CoS 09246 along with two standard varieties, *viz.,* CoJ 64 and CoPant 84211 were evaluated for their rationing ability. The genotype CoLk 09202 had shown significant higher cane yield (74.0 t/ha) and CCS yield (8.3 t/ha) followed by CoPb 09181. Among the standard varieties, CoJ 64 was the best for cane yield (42.3 t/ha) as well as CCS yield (4.76 t/ha).

Seed multiplication: The seed of ten genotypes, *viz.,* Co 12026, Co 12027, CoH 12261, CoLk 12201, CoLk 12202, CoLk 12203, CoLk 12204, CoPant 12221, CoPant 12222 and CoS 12231 was multiplied for next year's IVT trial. The planting material of 2013 series for AICRP (S) was also brought from SBI, RC, Karnal and planted in the field for multiplication at IISR, Lucknow.

Evaluation of midlate sugarcane clones for North West Zone

Initial Varietal Trial (Midlate): Thirteen genotypes, *viz.,* Co 11026, Co 11027, CoH 11263, CoH 11264, CoLk 11204, CoLk 11205, CoLk 11206, CoPb 11181, CoPb 11182, CoPb 11213, CoPb 11214, CoS 11231 and CoS 11232, along with three standards CoS 767, CoS 8436 and CoPant 97222, were evaluated for yield and quality parameters. The genotype CoH 11263 recorded the highest cane yield (88.7 t/ha), followed by CoLk 11204 (88.1 t/ha) and CoLk 11205 (87.9 t/ha). The genotype, CoH 11263 showed the highest CCS yield (11.4 t/ha), followed by CoH 11264 (11.0 t/ha) and CoS 11231 (11.0 t/ha). Among the test genotypes, CoH 11263 recorded the highest sucrose percentage at harvest (18.7%), followed by CoS 11231 (18.6%) and CoH 11264 (18.4%). Among the standard varieties, CoPant 97222 recorded the highest CCS yield (9.8 t/ha), followed by CoS 8436 and CoS 767.

Advanced Varietal Trial (Midlate) I Plant: A trial comprising of five genotypes, *viz.,* Co 10036, CoH 10262, CoPb 10181, CoPb 10182 and CoPant 10221 along with three standard varieties CoS 767, CoS 8436 and CoPant 97222, was conducted for their evaluation. The genotype, CoH 10262 recorded the highest cane yield (87.9 t/ha), which was significantly better than the best check. CoH 10262 exhibited the highest sucrose % at 12 months (18.6%), followed by CoPb 10181 (18.4%) and CoPant 10221 (18.2%). Among the standard varieties, CoPant 97222 was found to be the best for both cane yield (72.2 t/ha) and CCS yield (10.0 t/ha).

Advanced Varietal Trial (Midlate) II plant: A trial comprising of five test genotypes, *viz.,* Co 09022, CoH 09264, CoLk 09204, CoPb 09214 and CoS 09232, along with three standard varieties, *viz.,* CoS 767, CoS 8436 and CoPant 97222 was conducted. Observations on yield and quality parameters were recorded. Genotype CoLk 09204 recorded the highest cane yield (93.3 t/ha), followed by CoH 09264 (92.1 t/ha) and CoS 09232 (90.3 t/ha). However, Co 09022 had shown the highest CCS yield (11.8 t/ha) followed by CoS 09232 (10.6 t/ha) and CoLk 09204 (10.3 t/ha). The genotype, Co 09022 showed the highest sucrose percentage at harvest (19.4%), followed by CoS 09232 (18.5%). Among the standards, CoS 767 was the best check for cane yield (75.8 t/ha) and CoPant 97222 for CCS yield (9.3 t/ha).

Advanced Varietal Trial (Midlate) Ratoon: Five genotypes, *viz.*, Co 09022, CoH 09264, CoLk 09204, CoPb 09214 and CoS 09232 along with three standard varieties, *viz.*, CoS 767, CoS 8436 and CoPant 97222 were also evaluated for their ratooning ability. The genotype CoH 09264 had significantly higher cane yield (84.6 t/ha) and CoS 09232 was the best for CCS yield (8.9 t/ha). Among the standard varieties, CoS 767 was the best for cane yield (71.3 t/ha) as well as CCS (7.3 t/ha).

Seed multiplication: The seed of 15 genotypes, *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 was multiplied for next year's IVT trial.

Evaluation of early maturing sugarcane clones for North Central and North Eastern Zone

Initial Varietal Trial (Early): Four entries, *viz.*, CoP 11436, CoP 11437, CoP 11438 and CoSe 1145 along with two checks (BO 130 and CoSe 95422) were evaluated for yield and quality attributes. The entries CoP 11436 and CoP 11437 were recorded to be superior over best check in sugar yield.

Advanced Varietal Trial (Early) II Plant: Four entries, *viz.*, BO 153, CoP 08436, CoSe 09452 and UP 09453 along with two checks (BO 130 and CoSe 95422) were evaluated for yield and quality attributes. The entry BO 153 showed superiority in sugar yield in plant crop.

Advanced Varietal Trial (Early) Ratoon: Four entries BO 153, CoP 08436, CoSe 09452 and UP 09453 along with two checks (BO 130 and CoSe 95422) were evaluated for ratoonability. The entry BO 153 showed superiority in sugar yield in ratoon crop.

Evaluation of midlate sugarcane clones for North Central and Eastern Zone

Initial Varietal Trial (Midlate): Seven entries, *viz.*, BO 155, CoP 11439, CoP 11440, CoSe 11453, CoSe 11454, CoSe 11455 and CoSe 11456 along with three checks (BO 91, CoP 9301 and CoSe 92423) were evaluated for yield and quality attributes. The entry CoSe 11455 showed superiority in sugar yield.

Advanced Varietal Trial (Midlate) I Plant: Three entries, *viz.*, CoSe 10451, CoSe 10452 and CoSe 10453 along with three standards (BO 91, CoP 9301 and CoSe 92423) were evaluated. None of the entries under test were superior over the best check. The entry CoP 9301 possessed superiority in sugar yield in plant crop.

Advanced Varietal Trial (Midlate) II Plant: Two entries, *viz.*, BO 154 and CoP 09437 along with three checks (BO 91, CoP 9301 and CoSe 92423) were evaluated for yield and quality attributes. The entry CoP 09347 exhibited superiority in sugar yield over best check.

Advanced Varietal Trial (Midlate) Ratoon crop: Two entries BO 154 and CoP 09437 along with three checks (BO 91, CoP 9301 and CoSe 92423) were evaluated ratoonability. None of the entries were significantly superior in sugar yield in ratoon crop.

Elucidation of the role of species chromosomal complement in sugarcane genotypes adapted to subtropical conditions

To understand numerical chromosomal variations in sugarcane and to decipher the contribution of species-specific chromosomes in elite genotypes, chromosome number variability studies were carried out in a sugarcane genotype CoLk 8102 and a cross population CoLk 8102 GC to find out the chromosome variation pattern in progeny clones and their field performance. The somatic chromosome squash preparations were scored for 2n chromosome numbers. The mean chromosome numbers per cell varied from 98-110 in CoLk 8102, along with the modal chromosome numbers of 2n=ca. 108. In the cross populations, the somatic chromosome number per cell ranged from 88-114. Optimization of probe preparation and hybridization was continued for *in situ* hybridization studies. The probe mixture prepared from genomic DNA of CoLk 1158 and BO 91 was hybridized separately with root-tip cells of plants from a cross CoLk 1158 × BO 91 under a cover slip as per recommended conditions. The slides were mounted with antifade solution. Detection of labelled sequences could not give confirmatory results. Either the signal intensity was very low or the signals were absent. The experiment needs further optimization.

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

The PCR-based strategy using primers derived from nucleotide binding site-leucine rich repeat (NBS-LRR) gene family was used to identify resistance gene analogs (RGAs) from sugarcane. Eight different primer combinations of degenerate primers designed from the conserved motifs of NBS-LRR regions were used to amplify genomic fragments from sugarcane using genomic DNA from five genotypes including one red rot resistant genotype, *viz.*, BO 91 and four red rot susceptible genotypes, *viz.*, CoJ 64, CoS 767, CoS 8436, Co 1148. PCR results revealed RGA gene expression with some of these combinations. Specific fragments excised from the agarose gels were purified and sequenced. The sequences were analyzed

computationally to reveal fifteen putative RGAs. The length of RGA fragments varied from 400 to 600 bp and they were 89-99% similar to *Saccharum* hybrid cultivar NBS/LRR resistance protein-like gene sequence, *Saccharum* hybrid cultivar resistance gene-like mRNA sequence and *Sorghum bicolor* hypothetical protein, mRNA sequences. Further sequencing of these PCR products is in progress, and new RGAs are expected to be identified.

Optimization of multiplex PCR tools for detection of major sugarcane diseases

A multiplex polymerase chain reaction (MPCR) system that included three primer pairs designed from the conserved region of ribosomal DNA was developed for red rot, smut and sugarcane grassy shoot diseases of sugarcane using genomic DNA of *C. falcatum, S. scitamineum* and SCGS disease affected sugarcane leaves. With this method, the three diseases could be detected simultaneously (Fig. 1.1). The concentrations of each primer were optimized for multiplexing and the results were consistent with standard PCR.

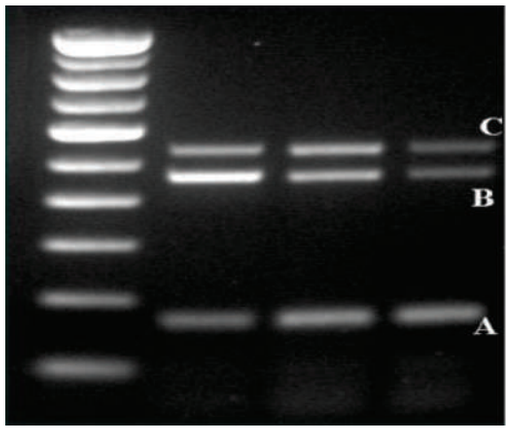


Fig. 1.1. Multiplex PCR of three sugarcane diseases; A: red rot, B: smut, C: SCGS phytoplasma

Standardization and profiling of small RNA transcriptome of sugarcane

To characterize small RNA transcriptome of sugarcane, total RNA was isolated from the leaves of CoS 8436 using TRIzol method and small RNA enrichment was carried out. This was subjected further to cDNA formation which was checked for amplification and used for small RNA library preparation. Analysis of small RNA libraries is underway.

Mapping of loci linked to sugar content in sugarcane

An existing population from a biparental cross of LG 94114 × ISH 176 consisting of 60 clones was evaluated for sucrose content. The pol % juice varied from 8 to 19%. A subset of clones (40 clones) with extreme values for sucrose content (Fig. 1.2) was selected and advanced further. Genotyping will be carried out in these clones with extreme values for sucrose content.

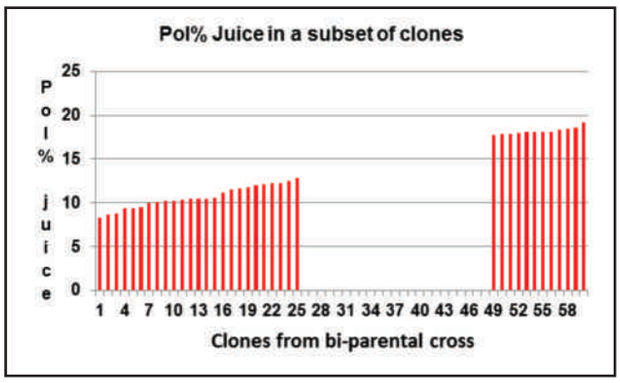


Fig. 1.2. Pol% juice values in a subset of clones from a bi-parental cross LG 94114 × ISH 176

Another segregating population from selfed population of CoLk 7901 in the C_2 generation was phenotyped for juice quality traits. Hand Refractometer Brix was recorded from October onwards and juice quality analyses were carried out during January and February 2015. The sucrose % juice values ranged from 9.2-19.8%. 7% of the clones had a mean sucrose % juice value less than 13, while 19% exhibited a mean sucrose % juice value more than 18. The combined phenotypic data for two years identified more than 70% of the clones with stable values for the trait.

Association mapping in sugarcane

The highly complex and polyploid sugarcane genome coupled with long breeding cycle hinders the understanding of its genetics, and therefore, molecular markers linked to traits of economic importance find immense applicability in sugarcane. In this study, a panel of 108 sugarcane genotypes from sub-tropical India was used to identify marker-trait associations (MTA) for sucrose and yield contributing traits based on Linkage Disequilibrium (LD) study. This study exploited a set of 989 SSR marker loci generated from 123 genomic- and expressed sequence tag-SSR primers and was based on a modified algorithm for population structure (Q) analysis (Fig. 1.3) coupled with the mixed linear model (MLM) for

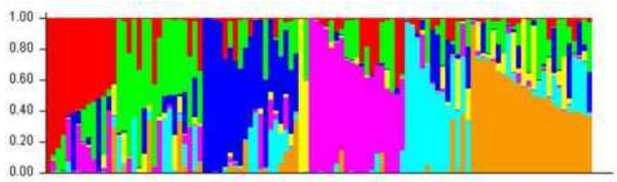


Fig. 1.3. Population structure pattern of 108 sugarcane genotypes

MTA identification using the software TASSEL. A total of fifteen SSR markers that were stable over the years were identified as shown in the Q-Q probability plots (Fig. 1.4).

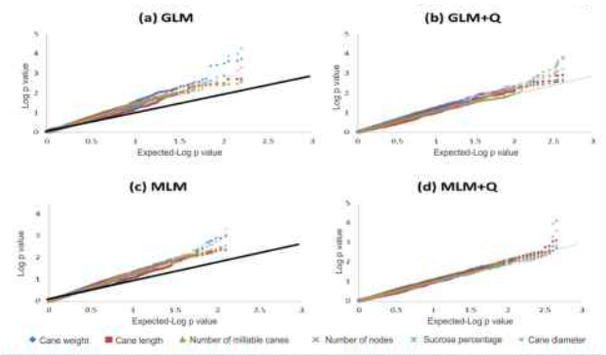


Fig. 1.4. Quantile-quantile (Q-Q) probability plots obtained with four models of MTAs applied on six yield contributing traits. Models used were: a) GLM, b) GLM + Q, c) MLM, d) MLM + Q (each single dot represents a marker)

These markers could explain 57% trait variation for NMCs, 34% for cane width, 27% for cane length, 20% for sucrose content, and 19% for number of nodes in the crop. The results were able to provide a deeper understanding of the genetics, population stratification and its manifestations on LD in the sugarcane genome and the identified MTAs could be exploited to fine-tune marker-assisted breeding programmes in near future.

Linkage disequilibrium-based association mapping of red rot resistance in sugarcane

Linkage disequilibrium or association mapping approach was used to identify four markers associated with red rot resistance, which is one of the most important diseases of sugarcane in India and several other south Asian countries. Efforts were also made to find out putative candidate genes potentially involved in plant-pathogen/stress interactions in the vicinity of sorghum homologs of sugarcane markers through comparative genomics study. A panel of 119 sugarcane accessions originated from 9 sugarcane breeding programmes around the sub-tropical India were screened for red rot reaction against pathotype CF 01 (Fig. 1.5). One hundred EST-SSR and gSSR polymorphic primers pairs were selected previously published reports, which generated 948 scorable markers (Fig. 1.6).

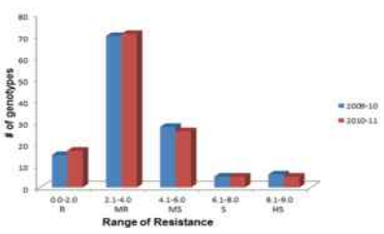


Fig. 1.5. Frequency distribution of phenotypic data of varieties/genotypes against red rot pathogen race CF 01

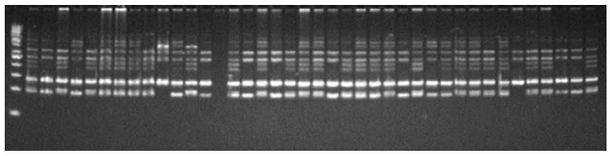


Fig. 1.6. Genotyping of the sugarcane varieties/genotypes with IISR_269 primer pair

Structure analysis was done using the software Structure Version 2.0 to be applied on non-diploid organisms. Linkage Disequilibrium (LD) decay, Kinship analysis and marker trait association by mixed linear model (MLM) was carried out using TASSEL Software. Analysis of red rot resistance in the association panel was assessed in cultivars/genotypes panel exposed to artificial inoculation in the epidemiological context of Lucknow. IISR_298a (having a strong association with red rot) was blasted with sorghum genome at e-10, only one hit was found on chromosome 7 of sorghum genome. A window of 100 kb sequence on both end of the marker was extracted using a python script. This selected 200 KB sequence was search for putative genes using FGENESH. Protein sequences of putative genes were blasted to NCBI database to identify their function and possibility of their role in plant defence responses. The results suggest that LD decay over short distances will facilitate fine mapping of QTL, while LD decay over longer distances will facilitate initial association of trait data with haplotypes in chromosome regions. Further, the LD map can be used as a reference to find target QTL and genes for positional cloning.

Production of disease-free quality seed cane production through micropropagation technique

The availability of disease-free genetically uniform seed cane has always been a concern in sugarcane cultivation since it is traditionally propagated through vegetative means. Micro-propagation has enabled rapid multiplication of varieties with premium traits, and production of disease-free and genetically uniform seed cane. 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) and 4.6 µM kinetin (Kin) + 3% sucrose. The maximum shoot proliferation per explant with 100% shoot regeneration frequency was

obtained on MS medium supplemented with 2.22 µM BA + 2.3 µM Kin + 26.8 µM naphthalene acetic acid (NAA) + 3% sucrose (Fig. 1.7). Vigorous rooting was obtained on MS medium containing 26.8 µM NAA and 5% sucrose. Plantlets were acclimatized in soil, sand and compost (1:1:1) for about 3 weeks and thereafter, transferred to open field (with >95% survival) where plantlets grew vigorously.

Fig. 1.7. Different stages of sugarcane micro-propagation

In this way, more than 20000 plantlets of varieties CoLk 07201, CoLk 9709 and CoLk 05011, have been transferred to field this year, where morphological evaluation is in progress. The sugarcane thus obtained from such micropropagated plantlets after one cycle of multiplication in the field could be distributed as genetically uniform seed cane. This micropropagation procedure could be useful for raising genetically uniform seed cane (breeder seed cane) having elite traits, to rapidly multiply newly released sugarcane varieties for distribution among the farmers.

Breeder seed production at IISR-RC, Motipur, Bihar

Phase I: During 2014-15, a total of 15660 q sugarcane breeder seed of six varieties were produced (Table 1.6).

Table 1.6. Variety-wise details of breeder seed production in phase I

Location	Variety	Area (ha)	BSP (q)
IISR, RC, Motipur, Bihar	CoLk 94184	1.75	610.1
	Co 0233	3.00	1282.5
	CoP 9301	0.25	111.3
Harinagar Sugar Mill, W. Champaran	CoLk 94184	3.82	2853.8
	Co 0232	5.84	3886.0
	CoP 9301	2.63	1894.9
	Co 0238	3.38	2175.0
	Co 0118	4.33	2847.2

Phase II: Indian Institute of Sugarcane Research (IISR), Lucknow signed a Memorandum of Understanding (MoU)-Phase II with Sugarcane Industries Department, Bihar Government for breeder seed production of improved sugarcane varieties on March 12, 2014 in Patna. For Second phase of MoU a total of rupees seventy five lakh (Rs 75.0 lakh) was granted by Govt. of Bihar to IISR, Lucknow. The seed crop was monitored for quality and genetic purity at different stages. During 2014-15, sugarcane breeder seed of seven varieties were produced (Table 1.7).

Table 1.7. Variety-wise details of breeder seed production in II phase

Name of Farm	Variety	Area (ha)	BSP (q)
IISR Regional Centre, Motipur	Co 0232	1.0	459.32
Hasanpur Sugar Mill, Narayanpur Farm, Hasanpur Samastipur	Co 0233	3.0	1500.0
	Co 0232	1.0	600.0
	Co 0238	2.0	1100.0
	Co 0239	1.0	550.0
	CoP 9301	1.0	550.0
	CoLk 94184	1.0	575.0
	BO 153	1.0	600.0

ICAR Seed Project: Seed production in agricultural crops

A total of 6000 q seed cane of improved varieties of sugarcane was produced (Table 1.8) out of which 5200 quintals seed cane of improved varieties of sugarcane was lifted and the rest was utilized for further multiplication and distribution to farmers. More than 10.0 ha area was planted with newly released varieties for seed cane supply during 2015-16.

Table 1.8. Sugarcane Seed Production at IISR, Lucknow during 2014-15

Variety	Maturity group	Quantity (q)
CoLk 94184	Early	1700
CoPK 05191	Early	2000
Co 0238	Early	500
Co 0118	Early	200
CoSe 03234	Early	200
CoLk 9709	Early	400
CoLk 07201	Early	100
CoPant 05224	Midlate	200
Co 05011	Midlate	400
CoH 128	Midlate	300
Total		**6000**

Central sector scheme for PPV&FR Authority

A total of 144 varieties and the AICRP (S) advance clones are under maintenance for the Reference Collection. Three candidate varieties were evaluated under DUS Testing. Two new clones along with reference varieties were transplanted in the field for DUS Testing. Two clones Desi No. 1 and Desi No. 2 are also being evaluated through grow-out test.

Developing sugarbeet varieties suitable for Indian agro-climates

This long-term project aims at acquisition, evaluation, utilization and maintenance of sugarbeet germplasm. The ultimate object is to develop and identify sugarbeet varieties suitable for cultivation under Indian conditions. The work is being carried out at two locations- at Lucknow for root crop trials for evaluating the potential varieties for commercial cultivation of sugarbeet, and at Mukteswar in Uttrakhand for breeding and seed production.

During the year 2014-15, a total of 56 germplasm lines comprising of inbreds, varieties, composites and elite selections, were raised for maintenance and seed production. A total of 37.0 kg of seed was harvested in July 2014, of which 30 kg belonged to the indigenously developed IISR variety, LS-6. Stecklings from the seed of 2014 harvest were raised at Lucknow and transplanted in December 2014 at Mukteswar. The seed, primarily of LS-6, was supplied to KVKs, two ICAR institutes, namely, CSSRI and IGFRI and for experimentation and demonstration at IISR. In January 2015, 53 sugarbeet germplasm lines were established for breeding studies and seed production.

2

High density cane farming

Optimization of plant population for improving physiological efficiency of sugarcane

Two experiments with sugarcane variety CoLk 94184 under autumn and late planting seasons were conducted for enhancing the plant population density and physiological efficiency through application of growth regulators right from planting stage to every critical growth stage. The applications enforced physiological enhancements at critical growth stages during the crop cycle, *viz.*, germination, tillering, grand growth stage and maturity. The overall impact of these applications in autumn planted crop manifested in enhanced plant population with strengthened physiological efficiency culminating in T_{max} 11.6 lakh tillers/ha as against 3.83 lakh tillers/ha in control at 180 DAP. Later, tiller survival of 61.8% culminated in an NMC of 4.43 lakh/ha with cane yield of 330 t/ha against tiller survival of about 60.8% resulting in NMC of 1.52 lakh/ha with a cane yield of 129 t/ha in control. With such an enormous synergistic impact of applications on plant population density and physiological efficiency, the gap in obtained yield (OY) and theoretical yield potential (TYP: 470 t/ha) has been cut short to just 29.7%. It is, thus, inferred that for minimizing the gap between OY and TYP, an optimum initial population of about 1 lakh shoots/ha, instead of 40,000 shoots/ha shall be able to sustain NMC of about 5 lakh/ha with improvement in physiological efficiency through hormonal interventions. In late planted crop, the hormonal interventions manifested in NMC of 94,000/ha with cane yield of 76 t/ha against NMC of 65,000/ha with a cane yield of 39.7 t/ha in control. The enormous synergistic impact of hormonal interventions on sugarcane yields were also demonstrated at two farmers' fields under Shamli Sugar Mill area in crop planted late after wheat harvest.

Hormonal interventions in autumn planted crop

At planting stage (October)- Hastening and improving germination through Ethrel (2-chloroethyl phosphonic acid): Overnight soaking of sugarcane setts in 100 ppm ethrel solution led to 46% germination at 40 DAP and an initial plant population of 91,267 shoots/ha as against 23% germination and a shoot population of 46,467/ha in control. ethrel triggered faster and higher germination at 40 DAP was ramification of enhanced (42.9%) mobilization of sucrose compared to that of control (18%), greater availability of 95.4% reducing sugars against 12.1% in control through enhanced acid invertase and ATPase activities by 486 and 78.7% as against 72.4 and 18% in control, respectively (Table 2.1).

At 60 DAP- Induction of horizontal growth through ethrel: Foliar application of ethrel (100 ppm) at 60 DAP triggered rapid flush of shoots/tillers enhancing the tiller numbers (1,56,467 per hectare) against control (72,667 per hectare), rendering the horizontal growth in the crop for enhancing the plant population. ethrel triggered flushing of shoots manifested as a consequence of activation of IAAO and NR *in vivo* activities in silent buds as evidenced by increase in their activities by 70.1% and 69.3% as against 9.9 and 8.6% in control, respectively.

Table 2.1. Crop growth stages and concentrations for phasic hormonal application for improving cane and sugar productivity

Crop growth stage	Growth regulator	Concentration (ppm)	Mode / Time of application
At planting	*Ethrel*	100	Overnight soaking of sugarcane setts
60 DAP			Foliar application of ethrel solution
70-90 DAP 120 -130 DAP 150 DAP	GA_3	35	Foliar application of GA_3 at specific leaf sites in morning (9.00 am-11.00 am) or in evening (after 4.00 pm)

At 90, 120 and 150 DAP- Induction of vertical growth through GA_3: As soon as sufficient horizontal growth in terms of number of tiller was achieved, the crop was subjected to vertical growth through foliar applications of 35 ppm GA_3 at specific leaf sites in morning (9 am-11 am) at 90, 120 and 150 DAP. Application of GA_3 at 90 DAP reduced the plastochron duration (5 d) generating vast canopy coverage (LAI-5), maximizing radiation use efficiency for stimulating increase in internodal number (16), internodal length (14 cm), cane weight (542 g) and girth (1.9 cm). The applications at 120 DAP further increased the number of internodes by 19, length (16 cm) and girth (2.1 cm) against internodal number (12), internodal length (8 cm), girth (1.4 cm) in control. Apart from strengthened physiological efficiency, the application at this stage also stimulated the crop to cope up with the high temperature stress that it passes during these days through intensifying and suppressing the SOD, ROS and MAD activities by 51.2, 12.3, and 11.8% against control, respectively. The application of GA_3 at 150 DAP further increased root weight (by 66% against control) and shoot development (the internodal numbers, length, girth, rate of stalk elongation) and also suppressed the formation of late tillers/water shoots (40%), a mechanism for reducing the photosynthates losses (Table 2.1).

Hormonal interventions in spring planted crop

Overnight primed three-bud setts with ethrel showed improved germination (46% after 45 DAP) over control (22%). Germination in water primed setts was only 29%. When whole cane was planted having similar level of treatments, germination was 58 (Ethrel), 38 (water) and 17% (control). GA_3 solution @ 35 ppm was sprayed at 90 and 120 DAP. With three bud setts, NMC and cane yield were 1.65 lakh/ha and 105 t/ha (ethrel primed + GA_3), 1.53 lakh/ha and 78 t/ha (water primed), 1.5 lakh/ha and 76 t/ha (control). With whole cane, NMC and cane yield were 1.33 lakh/ha and 104 t/ha (ethrel primed + GA_3), 1.45 lakh/ha and 77 t/ha (water primed), 1.4 lakh/ha and 81 t/ha (control).

Impact of primed planting on I ratoon

First ratoon crop of spring planted primed cane (Variety CoLk 94184) showed a higher survival of tillers and cane yield over control and water primed cane. The NMC (Lakh/ha) in control, overnight water soaked, 100 ppm ethrel and 200 ppm ethrel primed setts were 1.13, 1.50, 1.76 and 1.78, respectively, whereas, cane yield (t/ha) was 55.1, 73.8, 78.8 and 88.9, respectively. No significant change in juice quality was recorded.

Hormonal interventions in late-planted crop after wheat harvest

After the harvest of wheat, sugarcane variety CoLk 94184 was planted in May, 2014 at 75 cm spacing, keeping the seed rate of 4.5 setts/m row length. Foliar applications of GA_3 (35 ppm) at specific leaf sites in morning (9 am - 11 am) was carried out at 90, 120 and 150 DAP. The applications rendered increase in number of leaves per plant, leaf area, number of internodes per plant and internodal length by 33.3, 48.1, 22.2 and 28.5%, respectively as against control. The enhancement in internodal length occurred due to increased activity of α-amylase (63%) and NR activity *in vivo* (71%). At maturity, after seven months, GA_3 applications led to an increase in cane weight, cane length and cane girth by 33.4, 31.4 and 41.6%, respectively as against control. The application of GA_3 suppressed the formation of late tillers/water shoots by 60%. An improvement in the juice quality (sucrose %, corrected brix and purity coefficient were 17.07, 21.1 and 90.07 as against 16.80, 18.92 and 88.88 in control) was recorded. The applications boosted the NMC/ha by 20.4% with an increase in cane yield by 47.0% as against control (Table 2.2).

Impact assessment at farmers' fields

The impacts of GA_3 applications were also demonstrated at farmers' fields under Shamli Sugar Mill area (Table 2.2). The application boosted the NMC and cane yield by 15% and 64% (Mundetkala village) and 22.7 and 77.2% (Goharni village), respectively as against control.

Technology for high density cane farming through appropriate agronomy, precision machines and superior varieties

a. Agronomic evaluation of promising genotypes of sugarcane

Field experiment was conducted to determine the response of different genotypes of sugarcane to varying nutrient application rates. The experiment consisted of nine treatment combinations with three genotypes, *viz.*, CoPb 08217, CoLk 09204 and CoS 08235 and three doses of fertilizer applications, *viz.*, 75, 100 and 125% of RDF (150, 60 and 60 kg N, P_2O_5 and K_2O/ha). All the three genotypes varied significantly for growth, yield, yield attributes and juice quality. The genotype CoLk 09204 recorded higher shoot count and NMC over CoPb 08217 and CoS 08235, however, a significantly higher cane yield (70.9 t/ha) was recorded with CoPb 08217 (Table 2.3). Levels of nutrient application showed significant effect only on NMC, cane length and cane yield. Addition of 125% RDF recorded the highest cane yield (68.5 t/ha),

Table 2.2. Impact of GA_3 applications on growth attributes and juice quality in late-planted sugarcane at IISR farm and at farmers' fields

Sample/ Location/ Village	Variety	Brix	Pol (%)	Purity (%)	Juice Ext (%)	Pol in cane (%)	Fibre (%)	P_2O_5 (ppm)	CaO (ppm)	Titrable acidity	pH	Single cane weight (g)
At ICAR- IISR Farm , Lucknow												
GA_3	CoLk	22.1	18.9	90.9	61.6	15.0	16.8	522	950	3.09	5.4	992
treated	94184											
Control	CoLk	21.6	18.8	87.5	57.5	14.7	17.8	449	1090	2.07	5.4	712
	94184											
At Farmers' fields, Shamli *GA_3 sprayed thrice @ 35 ppm at monthly intervals*												
Mundet	CoS	19.2	18.8	87.3	65.5	13.6	14.0	568	1220	2.04	5.3	1000
Kala (Treated)	95422											
Mundet	CoS	17.7	16.0	86.0	63.6	12.5	14.8	481	1300	2.09	5.4	435
Kala (Control)	95422											
Goharni	CoP	19.2	19.0	86.5	68.1	11.3	12.8	463	1300	2.00	5.3	930
(Treated)	84212											
Goharni	CoP	16.7	16.7	85.1	64.7	13.4	14.7	371	1650	1.88	5.3	364
(Control)	84212											

however, similar cane yield (65.7 t/ha) was also observed with the application of 100% RDF. Juice quality parameters were not affected by fertilizer doses.

b. Priming cane node for accelerating germination

Experimental results indicated that the priming of cane nodes with hot water (50°C) + 3% urea solution for 2 h or in a mixture of cattle dung, cattle urine and water in 1:2:5 ratio and planted directly in the field or after incubation (4 d) gave significantly higher germination of cane buds (70.47%) as recorded 45 days after planting as compared to un-primed cane nodes (55.81%) or a treatment with hot water at 50°C for 2 h only (51.47%). Conventionally planted crop with 3-bud setts produced the lowest germination (44.1%). Number of tillers, millable canes and yield of cane also exhibited the same trend as the germination of cane buds obtained in different treatments. Accordingly, cane yield obtained under priming followed by incubation was found significantly higher by 13.4 and 11.8% over that with planting of unprimed cane nodes and treated with hot water only, respectively. Conventional planting with 3-bud setts although produced cane yield (75.8 t/ha) at par with primed cane node treatments (76.4 t/ha) but with the use of huge seed cane (72 q/ha), whereas, only 17.52 q/ha seed cane was used in cane node planting method.

Table 2.3. Plant growth, yield attributes, cane yield and quality of juice as affected by different genotypes and fertilizer doses

Treatment	Germination at 45 DAP (%)	Number of tillers (k/ha)	NMC (k/ha)	Cane yield (t/ha)	Cane length (cm)	Cane diameter (cm)	Pol (%)	Purity (%)	CCS (%)	CCS (t/ha)
Genotype										
CoPb 08217	35.0	137.2	101.7	70.9	227.3	2.69	18.0	87.1	12.36	8.8
CoLk 09204	33.8	149.4	117.9	63.6	215.1	2.45	16.6	85.5	11.30	7.2
CoS 08235	33.7	148.2	103.6	63.7	210.2	2.61	16.7	84.9	11.35	7.2
CD (5%)	NS	6.05	4.58	5.23	11.8	0.15	0.8	0.93	0.45	0.6
Fertilizer dose										
75% RDF	34.2	141.8	105.0	63.9	212.9	2.48	17.0	85.8	11.57	7.4
100% RDF	34.2	146.4	107.0	65.7	218.1	2.62	17.1	85.8	11.68	7.7
125% RDF	34.0	146.5	111.0	68.5	221.7	2.66	17.2	86.1	11.76	8.1
CD (5%)	NS	NS	4.58	5.23	11.8	NS	NS	NS	NS	NS

RDF: Recommended dose of fertilizers

Sugarcane yield maximization through optimizing shoot population density

Component I: Regulating shoot population dynamics for high cane productivity

Field experiment was conducted to conceptualize tillering dynamics for enhanced productivity of sugarcane in spring planting season.The experiment consisted of 16 treatment combinations, *viz*., four row-spacings (120, 90, 75 and 60 cm) and four techniques of placement of the planting material (seed) (conventional three bud sett, parallel sett placement with 30 cm sett-to-sett spacing, pre-sprouted single cane node planting at 25 cm spacing and pre-sprouted 3 cane node planting at 25 cm spacing).

cm, which was closely followed by 75 cm spacing (73.9 t /ha). The yield attributing characters, *viz*., cane girth and average cane weight were significantly reduced at 60 cm spacing, however, cane length was not affected by row spacing (Table 2.4). Placement of three pre-sprouted cane node at one place at 25 cm spacing recorded significantly higher ratoon shoot count (274.5 k/ha at 150 DAP), number of millable canes (130.4 k/ha) and cane yield (70.4 t/ha). The juice quality parameter, *viz*., brix, pol %, purity % and CCS% were not affected by row spacing, however, a significantly higher ratoon sugar yield (8.21 t/ha) was recorded at 60 cm spacing which was comparable to 75 cm spacing (Table 2.5). The CCS (t/ha) was observed to be higher when three pre-sprouted cane nodes bunch was placed at 25 cm (7.49 t/ha). Observations

Table 2.4. Effect of row spacing and seed placement techniques on growth and yield parameters of sugarcane ratoon

Treatment	Shoot population (k/ha)			NMC (k/ha)	Cane length (cm)	Cane girth (cm)	Single cane weight (kg)	Yield (t/ha)
	90 DAI	120 DAI	150 DAI					
Row spacing (cm)								
S_1 -120	150.7	173.9	199.2	80.3	237.1	2.75	0.92	48.1
S_2 – 90	163.4	192.5	240.0	112.5	237.2	2.62	0.88	61.9
S_3 – 75	215.4	223.5	259.3	133.1	236.6	2.54	0.77	73.9
S_4 – 60	249.5	248.5	316.6	134.9	235.1	2.35	0.73	76.7
CD (5%)	18.70	16.67	18.23	4.4	NS	0.32	0.19	4.73
Seed placement								
P_1 – Conventional	174.4	185.7	238.5	106.4	233.3	2.51	0.81	61.7
P_2 – Parallel sett placement	183.6	191.3	244.5	106.6	232.4	2.54	0.81	63.0
P_3 – Cane node at 25 cm	196.6	214.5	257.6	117.4	238.4	2.57	0.81	65.6
P_4- 3 cane node bunch at 25 cm	224.3	247.0	274.5	130.4	242.0	2.64	0.86	70.4
CD (5%)	18.7	16.67	18.23	4.37	NS	NS	NS	4.7

DAI: days after initiation

The data on ratoon sugarcane growth, yield attributes and ratoon cane yield indicated significantly higher shoot population (316.6 k/ha at 150 DAI), number of millable canes (134.9 k/ha) and cane yield (76.7 t/ha) were recorded at closer row spacing of 60 on combined effect of row spacing and seed material placement treatments clearly indicated that placement of three pre-sprouted cane node bunch at 25 cm distance in 60 cm row spacing recorded the highest number of millable canes (150.3 k/ha) as well as ratoon cane yield (81.4 t/ha).

Table 2.5. Effect of row spacing and seed placement on cane juice quality and sugar yield in sugarcane ratoon

Treatment	Brix	Pol (%)	Purity (%)	CCS (%)	CCS (t/ha)
Row spacing (cm)					
S_1 -120	18.40	15.83	86.3	10.80	5.2
S_2 – 90	17.63	15.04	85.2	10.22	6.3
S_3 – 75	17.77	15.18	85.4	10.32	7.6
S_4 – 60	18.32	15.70	85.8	1070	8.2
CD (P=0.05)	NS	NS	NS	NS	0.7
Seed placement					
P_1 – Conventional	17.9	15.4	85.7	10.46	6.4
P_2 – Parallel sett placement	18.1	15.5	85.8	10.57	6.7
P_3 – Cane node at 25 cm	18.0	15.3	85.2	10.40	6.8
P_4- 3 cane node bunch at 25 cm	18.1	15.6	85.9	10.62	7.5
CD (5%)	NS	NS	NS	NS	0.7

Component II: Modified plant geometry in sugarcane by introducing intra-row spacing to ensure higher population and productivity

The field experiment was conducted during 2014-15 to study the effect of treatments imposed in plant crop on the succeeding ratoon crop. Sixteen treatments were imposed in plant crop in RBD (factorial) with three replications. The treatments combinations were: planting material, *viz.*, three budded setts and two budded setts; planting geometry (sett placement in furrows keeping intra-row spacing), *viz.*, two setts at 20 cm, two setts at 30 cm, three setts at 30 cm, and conventional; sett treatment, *viz.*, setts treatment (overnight soaking) with resorcinol @ 0.1% and control (conventional).

The experimental findings revealed that tiller population in ratoon crop recorded in the months of May, June and July were not affected by either planting material or planting geometry or sett treatment. In general, tiller population in ratoon crop increased till the month of June, and thereafter, it started declining mainly due to tiller mortality. Stalk population recorded in the months of August, September and NMC at harvest were significantly higher in the treatment of introduction of intra-row spacing as compared to conventional planting might be due to less tiller mortality in these treatments. The yield attributes like cane length, cane weight and cane diameter were statistically at par in all the treatments. Sugarcane ratoon yielded significantly higher in the treatment where intra-row spacing was introduced in planting. The highest ratoon yield (83.6 t/ha) was recorded in the treatment where sugarcane was planted by placing three setts at intra-row spacing of 30 cm compared to those of conventional planting (74.1 t/ha). The placement of two setts keeping intra-row spacing of 20 cm or 30 cm in planting also helped in significant augmentation of sugarcane ratoon yield over ratoon from conventional planted cane (Table 2.6). Different treatments imposed in plant crop did not alter cane juice quality parameters in ratoon crop.

Table 2.6. Different treatments imposed in plant cane and their effect on succeeding ratoon crop

Treatment	Tiller population (k/ha)					Cane length (cm)	Cane diameter (cm)	Single cane weight (g)	NMC (k/ha)	Cane yield (t/ha)
	17.5. 2014	20.6. 2014	19.7. 2014	21.8. 2014	15.9. 2014					
Planting material										
Two-bud setts	188.0	206.3	183.6	131.0	118.0	211	2.29	859	107.5	79.0
Three-bud setts	191.1	210.9	189.2	132.5	122.3	213	2.30	866	110.2	81.3
SE	3.79	3.81	3.62	2.10	2.01	2.6	0.02	8.0	2.3	1.3
CD (5%)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Planting geometry (Sett placement in furrows keeping intra-row spacing)										
Two setts at 20 cm	188.8	208.5	185.6	131.7	120.3	212	2.29	867	109.6	81.2
Two setts at 30 cm	190.4	209.3	184.4	131.0	120.5	215	2.32	873	108.6	81.6
Three setts at 30 cm	198.4	218.1	197.0	141.5	131.3	212	2.30	858	121.1	83.6
Conventional (end-to-end)	180.4	198.5	178.5	122.8	108.6	209	2.26	851	96.3	74.1
SE	5.36	5.38	5.12	2.96	2.84	3.7	0.03	11.4	3.2	1.8
CD (5%)	NS	NS	NS	8.55	8.15	NS	NS	NS	9.37	5.17
Sett treatment										
Treated	189.4	207.9	187.1	131.3	119.2	211	2.28	858	108.1	79.5
Control	189.6	209.3	185.6	132.2	121.1	213	2.30	866	109.7	80.7
SE	3.9	3.81	3.62	2.10	2.01	2.6	0.02	8.0	2.3	1.3
CD (5%)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

3

Natural resource management

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

An experiment in 2nd cropping season was initiated in February 2014. Before planting of sugarcane (variety CoPK 05191), subsoiling (up to depth of 50 cm) and deep tillage through mould board plough (up to 20-25 cm depth) as per treatments were applied. 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 replicated thrice in RBD and evaluated in sugarcane plant crop.

Experimental results revealed that deep tillage and subsoiling followed by harrowing before sugarcane planting increased the number of millable canes (1,29,700/ha), cane length (240.8 cm), cane diameter (2.42 cm) and individual cane weight (1254.4 g) over other treatments (Table 3.1). Mean increase of 11.2% in sugarcane (97.3 t/ha) and 10.32% in sugar yields (12.0 t/ha) was obtained with adoption of deep tillage, subsoiling and harrowing over the farmers' practice (control). Sugarcane quality parameters did not show tangible differences among the various treatments. Initial subsoiling up to 50 cm and deep tillage through mould board plough up to 20-25 cm depth increased sugarcane growth attributes. Direct planting through sugarcane planter yielded statistically at par with farmers' practice and indicated the scope of cost reduction in initial field preparation.

Table 3.1. Effect of pre- and post-tillage operations on cane growth, yield attributes and soil health parameters in sugarcane (plant crop) at harvest

Treatment	NMC (k/ha)	Cane length (cm)	Cane diameter (cm)	Single cane weight (g)	Cane yield (t/ha)	Sugar yield (t/ha)	SOC (%)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
A. Pre-plant tillage*										
T_1: DP+Harr	129.7	226.70	2.53	1181.5	92.8	11.2	0.37	183.73	31.40	227.21
T_2: SS+DP+H	138.4	240.83	2.42	1254.2	97.3	12.0	0.40	210.31	28.44	226.72
T3: Sugarcane planter	111.6	231.67	2.45	1206.5	82.7	10.3	0.43	235.21	32.70	237.11
T4: Control	113.1	213.50	2.46	1092.5	87.4	10.9	0.35	185.33	31.59	216.58
SE	3.32	3.56	0.03	41.2	2.5	0.2	0.008	2.80	0.56	4.25
C.D.(5%)	8.31	8.92	0.09	103.2	6.2	0.6	0.025	8.40	1.63	12.56
B. Post-plant tillage/operation										
TMH	119.8	237.73	2.48	1202.5	93.4	11.3	0.37	196.45	30.99	236.64
IWM	111.6	218.62	2.46	1164.8	86.7	10.9	0.42	210.83	31.07	217.16
SEm±	4.69	5.04	0.05	58.28	3.5	0.28	0.01	2.10	0.68	4.68
CD (5%)	NS	NS	NS	NS	NS	NS	0.032	NS	NS	NS
Initial level							0.50	323.23	57.1	378.89

*A. Pre-plant tillage treatments: T_1: Deep ploughing (20-25 cm) followed by harrowing (DP + Harrowing), T_2: Subsoiling (45-50 cm), disc ploughing and harrowing (SS + DP + H), T_3: Direct planting at optimum soil moisture through deep furrow sugarcane planter, T_4; Farmers' practice (Control) B. Post-plant tillage: TMH: Three manual hoeings (recommended practice); IWM: 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)

Post-tillage practices for weed management in crop indicated that there were no significant differences among almost of the growth attributes of sugarcane and sugar yields between three manual hoeings and integrated weed management practices (atrazin 2 kg ai/ha (PE) followed by 2,4-D @ 1 kg ai/ha, post-emergence and one hoeing. The highest cane and sugar yields (93.35 and 11.32 t/ha, respectively) were obtained with adoption of 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 (Table 3.1). After harvesting of plant crop, soil organic carbon did not differ significantly with pre-plant tillage treatments. Although, soil organic carbon (0.43%), available N (235.21 kg/ha), P_2O_5 (32.7 kg/ha) and K_2O (237.11 kg/ha) were analyzed at the highest level where direct planting at optimum soil moisture through sugarcane planter was followed. It was due to the minimum tillage which reduced oxidation of carbon and improved the availability of nutrients.

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

Experiment was conducted to analyse the long-term effect of sugarcane cultivation on soil health parameters and crop productivity. Soil organic carbon (0.58%) improved in sugarcane-based cropping system (sugarcane-ratoon-wheat) as compared to rice-wheat cropping system (0.45%) in 0-15 cm depth (Fig 3.1). The similar trend was also observed in 15-30 cm depth of soil. The higher levels of available nutrients (NPK) were also observed in the plots of sugarcane-based system as compared to rice-wheat system after two years crop cycle. Crop residue management with application of *Trichoderma viride* favoured higher accumulation of organic carbon besides improving crop growth and yield. Total carbon content also improved with adoption of crop residues management with *Trichoderma* in sugarcane-based system as compared to rice-wheat cropping system.

Soil microbial biomass carbon improved to a level of 2248.89 mg CO_2-C/g soil/day with adoption of crop residues management along with *Trichoderma* in sugarcane-based system (Fig. 3.1). In addition, improvement in soil respiration and soil microbial biomass nitrogen was also observed (Fig. 3.2).

During 2014-15, sugarcane planting was done on 15th April 2014 as succeeding crop in sugarcane-ratoon-wheat and 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 etheral solution for 4 h and S_4: Foliar application of 100 ppm ethereal and mixture of 1% urea on seed cane, one week prior to planting) and two levels of microbial consortia (M_1: Control; M_2: Application of microbial consortia (PSB + *Gluconacetobacter* + *Trichoderma*).

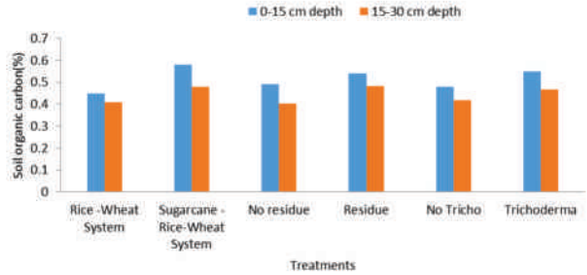


Fig 3.1. Effect of various treatments on soil organic carbon (%) after completion of two years crop cycle

Experimental results on plant crop revealed that under late planting situation sugarcane growth attributes, millable canes, length, diameter and individual cane weight were improved by foliar application of 100 ppm etheral, 1% urea on seed cane, one week prior to planting and application of microbial consortia (PSB + *Gluconacetobacter* + *Trichoderma*) over conventional 3 bud setts planting (Table 3.2). Foliar application of 100 ppm etheral, 1% urea on seed cane one week prior to planting increased number of millable canes up to 130 k/ha as compared to 92,670/ha in control (3 bud setts planting). There was an increase of 9.84% for number of millable canes (1,18,170 per hectare) with application of microbial consortia (PSB + *Gluconacetobacter* + *Trichoderma*). Thus, the highest cane and sugar yields (66.5 and 7.77 t/ha, respectively) could be obtained with foliar application of 100 ppm etheral with 1% urea on seed cane one week prior to planting over control plots (51.83 and 6.19 t/ha, cane and sugar yields, respectively).

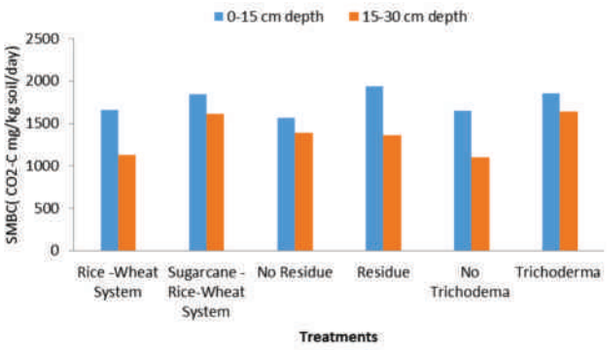


Fig. 3.2. Effect of various treatments on soil microbial biomass carbon after completion of two years crop cycle

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

Treatment	NMC (k/ha)	Cane length (cm)	Cane diameter (cm)	Single cane weight (g)	°Brix	Pol (%) juice	Purity (%)	Cane yield (t/ha)	CCS (t/ha)
A. Seed treatment									
S_1	92.67	166.67	1.83	505.2	20.38	17.49	85.99	51.8	6.2
S_2	109.67	181.50	1.93	558.0	20.97	18.11	86.39	58.0	7.2
S_3	119.17	175.50	1.84	591.8	20.33	17.34	85.29	61.5	7.2
S_4	130.00	192.67	1.97	637.3	20.06	17.15	85.50	66.5	7.8
S.E.	1.19	0.83	0.01	3.2	0.07	0.08	0.15	0.3	0.1
C.D. (5%)	3.60	2.51	0.02	9.7	0.21	0.25	0.44	0.8	0.2
B. Microbial consortia									
M_1	107.58	173.75	1.84	547.9	20.57	17.67	85.86	56.7	6.8
M_2	118.17	184.42	1.95	598.3	20.29	17.37	85.73	62.3	7.4
S.E.	1.19	0.83	0.01	3.21	0.07	0.08	0.15	0.25	0.05
C.D. (5%)	3.60	2.51	0.02	9.72	0.21	0.25	0.44	0.75	0.16
Interaction	NS								

*A. S_1-Control (3 bud setts), S_2- sett soaking in water, S_3- sett soaking in 100 ppm ethereal for 4 h, S_4 - foliar application of 100 ppm etherel and 1% urea on seed cane one week prior to planting
B. M_1- Control, M_2 - consortia application (PSB + Gluconacetobacter + Trichoderma)

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

a. Assessment of soil fertility status of sugar mill command areas of sub-tropical India

Soil samples from sugarcane fields were collected from the Sugar Mill Command areas located in the western and central parts of Uttar Pradesh and analysed for soil fertility status along with physico-chemical properties. Soil pH in command areas of sugar mills of eastern UP varied from 7.4-7.9 indicating suitability of the soils for sugarcane cultivation. Soils in central UP were found to have pH between 7.1 and 7.3, whereas, in the western UP, it varied between 7.1 and 7.9 (Table 3.3). Electrical conductivity of the soil from sugarcane growing areas of eastern, central and western UP sugarcane was found to be non-saline. Organic carbon content in these soils varied from being low to medium and on an average, the top soil contained <0.5% organic carbon in the eastern UP sugar mill areas. In soil samples from central UP, organic carbon content was found to be the lowest in Sitapur district (0.38%), whereas, the highest (0.62%) was recorded in Lakhimpur area. Soils samples from sugarcane growing areas of western UP contain soil organic carbon from 0.53 to 0.74% in different sugar mill areas. Available soil nitrogen content showed a similar trend in different regions of UP as that for soil organic carbon, however, overall, it was determined to be low in all the soil samples. Available P was rated to be low (13.1 to 18.7 kg/ha P_2O_5) for soils samples from eastern UP, medium (42.8 to 50.8 kg/ha) for central UP and medium to high (47.1 to 59.7 kg/ha) for the western UP. Exchangeable K was recorded to be in medium range (120-280 kg/ha) for soil samples collected from sugarcane fields of the eastern and central UP sugar mill areas, however, the western UP soils contained comparatively higher K led by Milakpur Sugar Mill, Baghpat, where it was determined to be 396.2 kg K_2O/ha. Among micronutrients, Zn was found to be deficient in sugarcane growing soils of Maharajganj and Deoria districts, where it was analysed to be lower than the critical limit (0.6 ppm). All other micronutrients were found to be higher than the critical limit in soil samples from sugarcane growing areas of UP.

b. Assessing nutrient interactions for sustaining sugarcane productivity and soil health

A field experiment was conducted during spring season of 2014-15 to assess nutrient interaction effect of nitrogen and potassium on sugarcane. Four levels of each nutrient *i.e.*, N; 0, 100, 150 and 200 kg/ha and K_2O; 0, 30, 60 and 90 kg/ha were taken in the study. Initial soil fertility was assessed to be low in available nitrogen and medium in available phosphorus and potash with pH 8.2 and electrical

Table 3.3. Soil fertility status of soil from sugarcane growing areas of Uttar Pradesh

Sugar mill zone	Soil pH	EC	OC (%)	Available N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)	Zn (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)
Eastern UP										
Gadaura, Maharajganj	7.8	0.10	0.40	219.2	13.1	139.5	0.37	1.49	28.30	9.55
Balrampur	7.4	0.11	0.45	234.9	20.6	195.6	0.92	1.48	38.36	19.37
Hata, Kushinagar	7.9	0.11	0.44	228.6	16.6	151.8	0.90	1.57	29.94	10.70
Kaptanganj, Deoria	7.7	0.11	0.47	237.1	18.7	180.2	0.57	1.34	24.63	14.21
Central UP										
DSCL, Hardoi	7.3	0.2	0.47	217.64	42.83	216.2	1.26	1.57	29.54	24.38
Rauzagaon, Faizabad	7.1	0.1	0.50	227.98	48.43	173.2	1.20	2.51	45.52	26.66
Bajaj, Lakhimpur	7.2	0.1	0.62	242.09	50.81	173.5	1.76	2.30	57.71	19.29
Biswa, Sitapur	7.1	0.1	0.38	225.47	49.28	166.0	1.44	1.88	27.00	24.45
Western UP										
Mawana, Meerut	7.1	0.1	0.65	271.57	59.78	224.8	1.86	1.63	46.28	35.19
Tikaula, Muzaffarnagar	7.8	0.3	0.53	249.93	58.55	232.7	2.84	1.74	38.47	21.40
Deoband, Saharanpur	7.2	0.1	0.61	259.03	47.13	236.8	1.70	2.14	40.13	33.38
Milakpur, Baghpat	7.9	0.2	0.74	280.98	52.81	396.2	3.19	2.47	23.12	32.52

conductivity 0.16 dSm^{-1}. The effect of interaction between nitrogen and potassium was not conspicuous on sugarcane growth and yield contributing parameters as well as on juice quality. Individually, both the nutrients significantly affected different parameters of cane growth and yield traits. Application of nitrogen and/or potassium significantly reduced germination in sugarcane. Although, shoot count (214.29 and 210.77 k/ha at 180 DAP), number of millable cane (188.1and 184.1 k/ha), cane length (197.38 and 192.97 cm), weight (527 and 548 g) and yield (78.9 and 74.4 t/ha, respectively) were recorded the highest at 200 kg N/ha and 90 kg K_2O/ha (Table 3.4). But these nutrient levels were at par with 150 kg N/ha and 60 kg K_2O/ha, respectively. Juice quality parameters, *viz.*, brix, sucrose % and purity % was not affected due to different doses of nitrogen and

Table 3.4. Effect of nitrogen and potassium on growth and yield attributes of sugarcane

Treatment	Germination at 45 DAP (%)	Shoot count at 180 DAP (k/ha)	Cane length (cm)	Cane diameter (cm)	Single cane weight (g)	NMC (k/ha)	Cane yield (t/ha)
Nitrogen (kg/ha)							
0	43.06	197.13	181.08	1.74	489	173.6	61.2
100	40.72	213.58	192.20	1.75	518	184.4	70.1
150	38.79	214.41	196.93	1.77	529	187.3.	76.9
200	37.41	214.29	197.38	1.77	527	188.1	78.9
SE	0.85	2.94	3.50	0.02	4.08	3.30	1.48
CD (5%)	2.46	8.49	10.11	NS	11.78	9.53	4.26
Potassium (K_2O k/ha)							
0	42.12	208.73	189.80	1.72	483	182.3	67.3
30	40.43	209.63	191.97	1.74	507	183.3	71.0
60	38.91	210.28	192.87	1.78	525	183.8	74.3
90	38.48	210.77	192.97	1.80	548	184.1	74.4
SE	0.85	2.94	3.50	0.02	4.08	3.30	1.48
CD (5%)	2.46	NS	NS	0.05	11.78	NS	4.26

The second field experiment was conducted to study the interaction effect of phosphorus and zinc in sugarcane during the spring season of 2014-15 with above soil fertility conditions. 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. Interaction effect of phosphorus and zinc was not significant. Application of $ZnSO_4$ 15 kg/ha along with 60 kg/ha P_2O_5 enhanced cane yield (80.5 t/ha; Table 3.5).

Table 3.5. Response of sugarcane in terms of yield (t/ha) to different levels of phosphorus and $ZnSO_4$

P_2O_5 (kg/ha)	$ZnSO_4$ (kg/ha)				Mean
	0	15.0	30.0	45.0	
0	68.4	71.8	74.1	75.6	72.5
30	73.2	75.9	79.1	79.3	76.9
60	75.3	80.5	78.5	78.7	78.1
90	75.1	78.6	77.0	77.3	776.
Mean	72.99	76.68	77.19	77.53	

CD (P=0.05) to compare phosphorus and zinc levels = 3.50

The increase in $ZnSO_4$ level to 30 kg/ha along with 60 kg/ha P_2O_5 reduced cane yield (78.5 t/ha) due to the antagonism between Zn and P. Whereas, cane yield improved with increase in Zn level from 15 to 30 kg/ha at the same level of P_2O_5 30 kg/ha but could not improve the yield at the same level of 60 kg/ha indicates mutual antagonism. Individually, both the nutrients improved growth and yield attributes of sugarcane.

c. Response of sugarcane crop to different plant nutrients in varied agroecological situations

Field experiment was planted during spring (February) of 2014. Soil of the experimental field was sandy loam (*Inceptisol*), neutral in reaction (pH 7.45), medium in available nitrogen (225.8 kg/ha) and potassium (191.0 kg K_2O/ha), low in organic carbon (0.40%) and phosphorus (17.24 kg P_2O_5/ha) contents. The experiment was laid out in RBD with thirteen nutrient combinations as treatments. Midlate maturing sugarcane variety CoSe 92423 was planted. 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 @ 40kg/ha), T_6: NPK + Zn (150:60:60 + $ZnSO_4$ @ 25kg/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) and T_{13}: only FYM @ 20t/ha.

Germination at 45 DAP was uniform in all the

Table 3.6. Effect of plant nutrient combinations on growth, yield and juice quality of sugarcane

Treatment	Germination (%)	NMC (k/ha)	Cane yield (t/ha)	Juice quality parameters at harvest		
				^{0}Brix	Sucrose (%)	Purity (%)
T_1 Control	51.4	72.17	63.1	18.89	16.23	85.95
T_2 N	47.7	81.06	63.6	18.55	15.99	85.81
T_3 NP	53.4	82.33	69.7	18.05	15.25	84.31
T_4 NPK	59.0	91.852	71.2	17.69	14.99	84.76
T5 NPK + S	54.4	96.51	81.4	18.49	15.81	85.52
T_6 NPK + Zn	56.3	105.19	82.8	17.33	14.45	83.33
T_7 NPK + Fe	53.4	95.77	77.2	18.40	15.69	85.24
T_8 NPK + Mn	56.3	96.08	75.0	18.33	15.61	85.12
T_9 NPK + S+ Zn	57.7	106.56	83.8	18.04	15.33	84.85
T_{10} NPK + S+ Zn+ Fe	55.7	110.48	89.2	16.95	13.71	80.71
T_{11} NPK + S + Zn+ Fe+ Mn	58.5	100.42	82.0	17.13	14.07	82.12
T_{12} STF	55.5	98.52	79.7	18.85	16.11	85.41
T_{13} FYM 20 t/ha	67.5	101.06	80.7	18.04	15.20	84.26
CD (5%)	9.9	16.325	13.3	NS	NS	NS

treatments, except those under FYM application and with combined application of NPK along with S, Zn, Fe and Mn being superior (Table 3.6). Initial shoot population, number of millable canes (NMC) at harvest and cane yield were significantly influenced by various nutrients applied. Application of NPK + S + Zn+ Fe produced significantly higher NMC (1,10,476 per hectare) and cane yield (89.2 t/ha) over the control (72169 NMC and 63.1 t/ha, respectively), which was 34.6% and 29.3% higher and was closely followed by NMC (1,06,561) and cane yield (83.8 t/ha) recorded with NPK + S + Zn.

d. 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, *viz.*, T_1 -No organic + 50% RDF (recommended dose of fertilizer), T_2- No organic + 100% RDF, T_3 - No organic + soil test-based recommendation (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 (rating chart) : 20 t + STRC, T_7 - Application of FYM/compost @ 10 t/ha + biofertilizer (*Acetobacter* + PSB) + 50% RDF : 10 t + B + 50% RDF, T_8- Application of FYM/compost @ 10 t/ha + biofertilizer (*Acetobacter* + PSB) + 50% RDF : 10 t + B + 100% RDF, T_9- Application of FYM/compost @ 10 t/ha + biofertilizer (*Acetobacter* + PSB) + 50% RDF: 10 t + B + STBR, T_{10} - only organic. The cane setts were soaked with biofertilizer cultures by dipping in the containers. FYM was applied in the furrows at the time of planting

The data on sugarcane growth, yield and quality indicated significant variations among the treatments (Table 3.7). A significantly higher rate of germination (39.6%) was observed under the treatment of biofertilizer application along with FYM. The highest number of tillers (132.7 k/ha at 120 DAP), shoot count (178.6 k/ha at 180 DAP), number of millable canes (123.2 k/ha), cane yield (98.0 t/ha) and sugar yield (12.3 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-based inorganic fertilizers application. The yield attributing characters, *viz.*, cane length (238.4 cm), cane girth (2.25 cm) and single cane weight (1.18 kg) was recorded significantly higher with the application of FYM @ 20 t/ha along with inorganic fertilizers applied on the basis of soil test rating chart. The quality parameters, *viz.*, brix value and pol % significantly improved with application of FYM and biofertilizers (Table 3.8).

Table 3.7. Germination, shoot population and yield of sugarcane as affected by different nutrient management treatments

Treatment	Germination (%) 45 DAP	Shoot population (k/ha)			NMC (k/ha)	Yield (t/ha)
		May	July	Sept.		
T_1: 50% RDF	35.2	90.2	130.9	139.6	87.26	60.5
T_2: 100% RDF	35.4	99.1	164.5	162.9	98.36	79.0
T_3: STBR	34.4	98.6	169.9	161.2	97.54	82.0
T_4: 20 t FYM + 50% RDF	38.2	98.5	166.3	159.7	93.56	73.1
T_5: 20 t FYM + 100% RDF	38.4	107.3	175.4	169.0	106.85	90.1
T_6: 20 t FYM + STRC	38.4	119.5	183.7	178.6	123.21	98.0
T_7: 10 t FYM + B + 50% RDF	39.6	99.3	176.5	169.1	101.69	78.8
T_8: 10 t FYM + B + 100% RDF	39.6	114.6	173.6	168.0	115.49	93.4
T_9: 10 t FYM + B + STRC	39.6	117.7	175.1	172.2	118.76	96.3
T_{10}: Organic	36.1	99.1	173.2	163.0	100.65	80.9
SE	0.61	3.20	4.69	4.55	2.84	2.3
CD (5%)	1.80	9.52	13.93	13.51	8.45	6.8

RDF: recommended dose of fertilizers; B: biofertilizers; STRC: soil test rating chart

Table 3.8. Effect of different treatments on juice quality, yield attributes and sugar yield

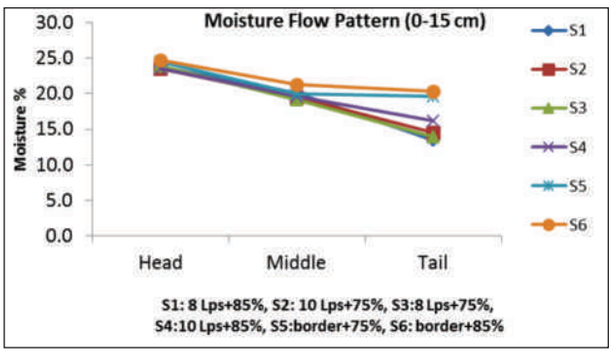
Treatment	Brix (%)	Pol (%)	Purity (%)	Cane length (cm)	Cane girth (cm)	Cane weight (kg)	CCS (%)	CCS (t/ha)
T_1: 50% RDF	18.55	15.69	84.40	207.67	2.10	0.90	10.61	6.4
T_2: 100% RDF	19.35	16.46	85.62	228.67	2.11	0.94	11.17	8.8
T_3: STRC	19.34	16.66	85.76	233.33	2.16	1.05	11.38	9.3
T_4: 20 t FYM + 50% RDF	19.16	16.34	84.89	221.00	2.16	1.09	11.11	8.1
T_5: 20 t FYM + 100% RDF	19.56	16.90	86.06	233.67	2.24	1.15	11.56	10.4
T_6: 20 t FYM + STRC	19.87	17.93	86.24	238.40	2.25	1.18	12.52	12.3
T_7: 10 t FYM + B + 50% RDF	19.26	16.41	85.46	222.00	2.17	1.12	11.14	8.8
T_8: 10 t FYM + B + 100% RDF	19.71	17.07	86.10	235.00	2.15	1.13	11.69	10.9
T_9: 10 t FYM + B + STRC	19.77	17.77	86.11	234.00	2.17	1.15	12.39	11.9
T_{10}: Organic	19.12	16.56	85.67	232.00	2.34	1.10	11.34	9.2
SE	0.40	0.46	1.07	6.21	0.06	0.03	0.29	058
CD (5%)	1.17	1.35	NS	18.44	0.18	0.09	0.87	1.73

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

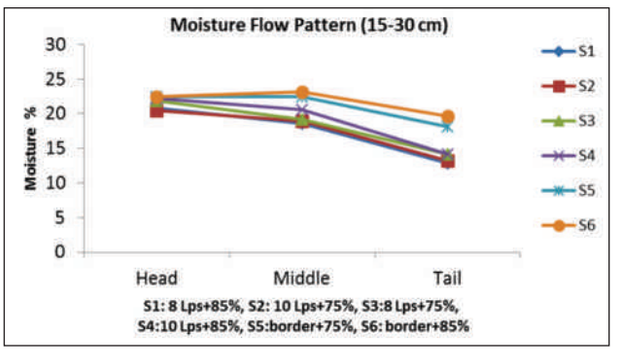
a. Rationalizing irrigation water use through optimizing field application parameters

The field experiment was conducted during spring season of the year 2014-15 to optimize the irrigation application parameters, *viz.*, furrow length, discharge rate and cut off length, respectively (in furrow irrigation system). The treatment consisted of two length of furrows (F_1- 50 m and F_2- 75 m) and six discharge and cut off length (D_1: Furrow- 8 Lps (litres per second) + 75% cut off length, D_2: Furrow- 10 Lps + 75% cut off length, D_3: Furrow- 8 Lps + 85% cut of length, D_4: Furrow- 10 Lps + 85% cut of length, D_5: Border - 75% cut off length and D_6: Border- 85% cut off length). The findings of the experiment resulted in bringing out the best irrigation application parameters with significant reduction in total water use. Soil moisture spread along the furrow, *viz.*, head, middle and tail region were also characterized (Fig. 3.3). Impact of different treatments on growth, yield and juice quality parameters were also observed and assessed.

Results revealed that the highest shoot count (157.9 k/ha at 150 DAP), number of millable canes (111.8 k/ha), cane yield (62.8 t/ha) and sugar yield (8.77 t/ha) were recorded with the discharge of 10 Lps + 85% cut off length. This combination also resulted in a higher IWUE of 2064.9 and 2414.5 kg/ha-cm in 50 m and 75 m furrow length, respectively. This combination also saved 41% of total irrigation water as compared to border irrigation method (farmers' practice). A strong correlation was observed between the total water use and yield. However, yield *per se*



(a)



(b)

Fig. 3.3. Moisture-flow pattern observed in two different soil depths under different discharge rates and cut-off length

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. 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.

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

Sugarcane ratoon crop was initiated during the second week of March 2014 and the crop was harvested in the first week of February 2015. It was observed that irrigation treatments significantly influenced shoot count at 60 and 120 days of ratooning (Table 3.9). However, nitrogen doses did not influence the shoot count. Irrigation × nitrogen interaction was also non-significant. Cane length, leaf, number of leaves per plant and the area of individual leaf were also significantly influenced by irrigation treatments but leaf width remained unaffected with irrigation and nitrogen treatments. However, total leaf area per hectare before onset of monsoon was significantly influenced by irrigation and nitrogen treatments. The irrigation treatments significantly affected number of millable canes. However, the effect of nitrogen and interaction of nitrogen × irrigation was non-significant for number of millable canes. Cane length was significantly influenced by irrigation and nitrogen treatments but cane stalk diameter was significantly influenced by irrigation treatments only. The highest sugarcane yield of 103.0 t/ha was obtained when sugarcane was drip fertigated with recommended dose of nitrogen and water equivalent to 125% pan evaporation (Table 3.10). However, irrigation water use efficiency (IWUE) was the highest at 2554.7 kg/ha-cm when fertigation was done and the amount of irrigation water was kept as 75% of pan evaporation (Table 3.11). The sugarcane yield and IWUE were not influenced significantly by doses of nitrogen in fertigation treatments but influenced significantly in surface irrigation. With surface irrigation, the mean sugarcane yield and IWUE were 70.0 t/ha and 874.49 kg/ha-cm, respectively (Table 3.11).

Table 3.9. Number of millable canes (k) as influenced by different irrigation regime

Irrigation	Nitrogen (per cent of recommended dose)			
	100	75	50	Average
I_1= Sub-surface drip at 75% PE	101.4	1021.0	100.2	101.2
I_2= Sub-surface drip at 100% PE	104.2	103.3	104.2	103.9
I_3= Sub-surface drip at 125% PE	112.0	108.5	113.9	111.5
I_4=Farmers practice	98.3	97.4	97.5	97.7
Average	1043.0	102.8	1043.0	
SE (Irrigation)				2.06
CD (Irrigation)				6.54
SE (N)				1.78
CD (N)				NS
SE (I×N)				2.06
CD (I×N)				NS

Table 3.10. Sugarcane yield (t/ha) as influenced by irrigation and nitrogen application

Irrigation	Nitrogen (per cent of recommended dose)			
	100	75	50	Average
I_1= Sub-surface drip at 75% PE	89.2	91.0	88.1	89.4
I_2 = Sub-surface drip at 100% PE	93.4	92.4	954.0	93.6
I_3 = Sub-surface drip at 125% PE	103.0	99.72	99.8	100.8
I_4=Farmers practice surface irrigation	765.0	70.6	63.2	70.0
Average	90.4	88.5	86.5	
SE (Irrigation)				1.18
CD (Irrigation)				3.75
SE (N)				1.02
CD (N)				4.40
SE (I×N)				1.18
CD(I×N)				2.89

Table 3.11. Irrigation water use efficiency (kg/ha-cm) due to different irrigation regime

Irrigation	Irrigation water (ha-cm)	Nitrogen (per cent of recommended dose)			
		100	75	50	Average
I_1= Sub-surface drip 75% PE	35.6	2505.5	2554.7	2475.0	2511.7
I_2 = Sub-surface drip 100% PE	47.5	1967.2	1946.2	1999.4	1970.9
I_3 = Sub-surface drip 125% PE	59.4	1733.6	1678.8	1679.8	1697.4
I_4= Farmers' practice	80	949.5	884.4	789.6	874.5
Average		1789.0	1766.0	1736.0	
SE (Irrigation)					21.1
CD (Irrigation)					67.1
SE (N)					18.3
CD (N)					78.6
SE (I×N)					21.1
CD(I×N)					51.6

Enhancing sugarcane productivity and profitability under wheat-sugarcane cropping system

The field experiment was conducted during 2013-15 to enhance the productivity of sugarcane under wheat-sugarcane cropping system. The experiment comprised of nine treatments *viz.*,T_1: Autumn planted sugarcane, T_2 : T_1+ wheat (1:2), T_3: T_1+ wheat (1:3), T_4: wheat sown on 15th November-late sugarcane, T_5: wheat sown on 15th December-late sugarcane, T_6: wheat sown (three rows) on 15th November under FIRB + sugarcane in furrows at 75 cm in 3rd week of February, T_7: wheat sown (three rows) on 15th November under FIRB + sugarcane in furrows at 75 cm in 3rd week of March, T_8: T_6 with sowing of wheat on 15th December and T_9: T_7 with sowing of wheat on 15th December was laid out. The findings revealed that wheat grain yield was the highest in November sown wheat in the treatment T_4 (Table 3.12). Wheat yield was at par in flat as well as FIRB method. However, wheat sown in the month of November yielded higher than wheat sown in December due to higher number of ear-heads per running meter, number of grains per ear-head and test weight. Wheat (November) + sugarcane (February/March) under FIRB method produced higher wheat yield (41.3 q/ha) over sugarcane (October) + wheat (November) in 1:3 row ratio (40.48 q/ha) as well as 2:1 row ratio (32.54 q/ha).

Tillering was the highest in the month of June and thereafter, it started declining due to its mortality. The highest tiller count (213.0 k/ha) was recorded in the month of June in autumn planted sole sugarcane followed by sugarcane planted in 3rd week of February with wheat under FIRB system (204.8 k/ha). Tiller count in autumn planted sole sugarcane and sugarcane planted with wheat in 3rd week of February

Table 3.12. Effect of different wheat-sugarcane systems on growth and yield of sugarcane

Treatment	Tiller count (k/ha)	Yield attributes at harvest				Cane yield (t/ha)	Wheat yield (q/ha)	CEY* (t/ha)	B:C
		Cane length (cm)	Cane dia. (cm)	Single cane weight (g)	NMC (k/ha)				
T_1 - Sole cane	213.0	220	2.39	887	110.3	77.4	-	77.4	2.04
T_2 - Sugarcane + Wheat (1:2)	102.1	191	2.36	767	85.4	56.0	32.54	78.9	1.79
T_3 - Sugarcane + Wheat (1:3)	86.3	190	2.33	757	79.8	49.3	40.48	77.8	1.75
T_4 - Wheat (Nov.) – Sugarcane	97.3	182	2.09	596	91.4	49.0	41.27	78.0	1.68
T_5 - Wheat (Dec.) - Sugarcane	92.2	179	2.11	604	90.8	50.6	34.64	75.0	1.62
T_6 - Wheat (Nov.) + Sugarcane (Feb) under FIRB	204.8	200	2.23	743	109.7	67.7	40.95	96.5	2.07
T_7 - Wheat (Nov.) + Sugarcane (Mar) under FIRB	158.9	193	2.21	703	105.1	57.6	41.30	86.6	1.86
T_8 - Wheat (Dec.) + Sugarcane (Feb.) under FIRB	199.7	202	2.20	747	112.5	68.8	32.70	92.2	2.00
T_9 - Wheat (Dec.) + Sugarcane (March) under FIRB	164.6	198	2.20	713	106.7	59.8	33.65	83.5	1.81
SEm±	4.18	4.07	0.031	6.73	3.34	2.0	-	-	-
CD (P=0.05)	12.5	12.2	0.09	20.17	10.0	6.0	-	-	-

*CEY: Cane equivalent yield calculated based on prices for sugarcane: ₹ 290/q; wheat grain ₹ 1450/q and wheat straw ₹ 500/q.

under FIRB system were at par but higher than sugarcane planted with wheat in 3rd week of March under FIRB (Table 3.13). The lowest tiller population (86.3 k/ha) was observed in sugarcane planted with wheat (1:3) under flat method followed by wheat–late sugarcane (97.3 k/ha) and sugarcane + wheat (1:2) system (102.1 k/ha). The cane yield was the highest (77.4 tonnes/ha) in autumn planted sole sugarcane. Sugarcane planted in 3rd week of February in standing wheat under FIRB method (67.7 t/ha) was significantly higher than sugarcane planted in 3rd week of March in wheat under FIRB and sugarcane + wheat (1:2) due to higher NMC, cane length and cane weight. The lowest cane yield was recorded in wheat–sugarcane system (49.0 t/ha) and sugarcane + wheat in 1:3 row ratio (49.3 t/ha). Cane equivalent yield (96.5 t/ha) and B:C ratio were the highest in sugarcane planted in 3rd week of February in wheat under FIRB method. Sucrose content in cane juice was significantly higher in autumn, February and/or March planted cane over cane planted after wheat harvest (Table 3.13). Other juice quality parameters like Brix and purity was not affected by the treatments. CCS % in cane was also statistically at for under all the treatments. However, autumn planted cane recorded the significantly highest CCS (t/ha) over rest of the treatments. Sugarcane planted on 3rd week of February in wheat under FIRB method achieved significantly higher CCS (7.9 t/ha) over sugarcane planted in 3rd week of March (6.7 t/ha) in wheat under FIRB method, sugarcane + wheat (1:2 or 1:3 ratio) and wheat-sugarcane system. Significantly the lowest CCS (t/ha) was recorded in wheat-sugarcane and sugarcane + wheat (1:3).

Table 3.13. Effect of different wheat-sugarcane systems on juice quality parameters of sugarcane

Treatment	Juice quality parameters			CCS (%)	CCS (t/ha)
	^{0}Brix	Sucrose (%)	Purity (%)		
T_1 - Sole cane	20.21	17.21	85.21	11.69	9.1
T_2 - Sugarcane + Wheat (1:2)	20.20	17.19	85.16	11.67	6.5
T_3 - Sugarcane + Wheat (1:3)	20.18	17.18	85.18	11.67	5.8
T_4 - Wheat (Nov.) - Sugarcane	20.06	17.05	85.04	11.57	5.7
T_5 - Wheat (Dec.) -Sugarcane	20.03	17.00	84.96	11.52	5.8
T_6 - Wheat (Nov.) + Sugarcane (Feb.) under FIRB	20.19	17.21	85.24	11.69	7.9
T_7 - Wheat (Nov.) + Sugarcane (Mar.) under FIRB	20.16	17.17	85.20	11.66	6.7
T_8 - Wheat (Dec.) + Sugarcane (Feb.) under FIRB	20.18	17.19	85.22	11.67	8.1
T_9 - Wheat (Dec.) + Sugarcane (Mar.) under FIRB	20.17	17.16	85.15	11.65	7.0
SE	0.06	0.05	0.16	0.04	0.24
CD (5%)	NS	0.14	NS	NS	0.73

Weather of 2014 at IISR, Lucknow

Weather parameters at IISR, Lucknow during the year 2014 are given in Table 3.14. In 2014, the maximum temperatures were invariably higher in January, February, March, October and December, and these were relatively lower in June and August. The minimum temperatures were higher as compared to normal in January only but these were lower in May, July, August, September, October and November. The year 2014 has received relatively higher rainfall in the months of January and October but lower rainfall in June, August and September. The RH at 7 hrs. in 2014 was higher in the months of January, February, March, April, October, November and December but it was lower in the months of May, August and September. The RH at 14 hrs. was higher in the month of January, February, March, October, November and December but it was lower in June, August and September as compared to normal.

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

Relationships between weather parameters and sugarcane yield and juice quality using the long-term data obtained from Upper Doab Sugar Mills, Shamli and the data obtained in AICRP (Sugarcane) experiments at IISR, Lucknow were worked out, InfoCrop Sugarcane Model was calibrated and validated, and long-term data concerning carbon sequestration in sugarcane were analysed.

- The juice quality (sucrose % juice) was affected by temperature (maximum and minimum) and rainfall. The sucrose % juice was lesser in 2009-10 as compared to other years (2008-09, 2010-11, 2011-12 and 2012-13) due to relatively higher rainfall, lower maximum and minimum temperatures during October 2009. Sugar

Table 3.18. Weather parameters during the year 2014 at IISR, Lucknow

Month	T_{max} (^{0}C)	T_{min} (^{0}C)	T_{range} (^{0}C)	Mean (^{0}C)	RH7 (%)	RH14 (%)	Mean (%)	BSS (hrs)	EVP (mm)	Wind (km/h)	Rainfall (mm)	Rainy days
January	18.1	9.8	8.3	14.0	96	70	83	0.8	0.9	1.8	47	3
February	22.3	10.8	11.5	16.5	93	52	72	3.2	2.2	2.8	23.2	3
March	30.1	15.1	15.0	22.6	81	36	58	6.3	4.3	4.1	9.2	1
April	37.0	19.9	17.1	28.4	57	22	39	6.4	7.6	5.0	0.6	0
May	39.5	22.8	16.7	31.1	54	31	42	6.3	9.2	4.8	21.2	2
June	40.3	26.4	13.9	33.4	70	38	54	3.0	7.5	3.7	22.2	2
July	33.8	22.9	10.9	28.4	87	70	78	0.4	3.9	2.3	264.0	12
August	34.5	24.2	10.2	29.4	86	63	74	NA	4.0	3.0	85.6	6
September	33.2	22.1	11.2	27.6	88	65	77	NA	3.2	2.3	88.8	4
October	31.1	15.4	15.7	23.2	95	59	77	NA	2.5	1.9	70.4	3
November	28.2	9.7	18.5	18.9	93	44	68	NA	2.0	1.5	0.0	0
December	20.4	7.8	12.6	14.1	94	61	78	NA	1.0	1.3	12.4	1

recovery in Shamli Sugar Mill was influenced by the range of temperatures during ripening phase (November to March) as well as grand growth phase (during July). With the increase in temperature range during November to March, sugar recovery increased, however, it decreased with increasing range of temperature in July.

- The InfoCrop-Sugarcane model developed with the help of the Centre for Environmental Sciences and Climate Resilient Agriculture, IARI, New Delhi. The model was calibrated and validated using the data obtained for Lucknow conditions. Simulated and observed data of phenology and cane yield matched to a fairly good degree.
- In a long-term experiment on carbon sequestration using organic manure, the maximum 1.26 t/ha/year carbon sequestration was observed with use of Sulphitation press mud (10 t/ha) as compared to 0.57 t/ha/year in NPK (150:60:60 kg/ha N:P:K) treatment and 0.31 t/ha/year in control.

4

Management of insect-pests and diseases

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

Survey was conducted for the incidence of insect-pests and diseases in the command area of various sugar mills of U.P., Bihar, Maharashtra and Chhattisgarh.

Incidence of diseases: In the command area of Balrampur Chini Mill group (Units: Balrampur and Tulsipur), incidence of red rot was observed in CoLk 8102 and CoS 8436 (>5.0%) and CoS 91269 (1.0%). Incidence of smut (5-10%) was observed in CoSe 92423, Co 0238, CoSe 1235, CoS 767 and CoS 98230 and Pokkah Boeng in Co 0238 and CoSe 92423. In the command area of DSCL Sugar Mill group (Unit: Rupapur), incidence of red rot was observed in CoLk 8102; smut in CoSe 92423 and Pokkah Boeng in Co 0238. Incidence of yellow leaf disease (YLD) was observed in CoJ 64, Co 7717, CoSe 92423, CoLk 94184, Co 0238 and Baragua (*S. officinarum*) at Institute farm. In the command area of Bhoramdeo Cooperative Sugar Mill, Kawardha (Chhattisgarh), severe incidence of mosaic was observed in Co 8036, Co 85004, Co 94008, Co 11024; grassy shoot disease (2-5%) in CoM 265, CoM 11086, Co 86032, Co 99004, Co 11020 and yellow leaf disease (YLD) in Co 86032, Co 99004 and CoVC 08063, respectively. In Bihar, red rot was also observed in BO 130 in Hasanpur Sugar Mill, Hasanpur and Pokkah Boeng in Co 0232 in Harinagar Sugar Mill, Harinagar.

Incidence of insect-pests: In the command areas of sugar mills of U.P., the incidence of early shoot borer (2-15%) and top borer (2-8%) were observed at DSCL, Rupapur. Incidence of Gurdaspur borer (2-5%) in CoPant 84212 and CoSe 95422 and white grub (2-10%) in CoS 767, Co 0238, Co 7250 was observed in the command area of Upper Doab Sugar Mill, Shamli.

In Kawardha area (Chhattisgarh), sugarcane fields were severely attacked by *Pyrilla purpusilla*. Egg parasite of *Pyrilla, Tetrastichus pyrillae* was present, but *Epiricania melanoleuca* was not observed. In Ahmednagar area of Maharashtra, incidence of scale insect was observed in one of the leading variety CoM 0265. The incidence of top borer and weevil was noticed at IISR-RC, Motipur, while low incidence of cane borers were observed in the command area of Harinagar Sugar Mill, Harinagar, Bihar.

Survey and surveillance of insect pests in sugarcane in Maharashtra (tropical India)

Survey was conducted for the incidence of insect-pests and diseases in different villages of area of various sugar mills of Maharashtra.

Seasonal prevalence of major insect-pests of sugarcane and their natural enemies

White Grub (*Holotrichia consanguinea*): Incidence of white grub was recorded in Kholar, Khandala, Nandur, Mamdhapur, Chinchpur, Dadh, Pathre and Fatyabad villeges which, in general, ranged from 4 to 10%. But, in some fields, the incidence was up to 75%.

Early shoot borer (*Chilo infuscatellus*): The incidence of early shoot borer was recorded in the command area of Pravaranagar Sugar Mill, throughout the year, with the highest incidence in the month of May (19.33%), followed by June (12.43%).

Woolly aphid (*Ceratovacuna lanigera*): The incidence of woolly aphid was recorded from three villages, *i.e.*, Mandave, Dadh and Mamdhapur. The incidence of woolly aphid was also noticed from the following villages: Kuranpur, Kadith, Mandave, Dadh, Kholar, Mamdapur, Loni and Ashivi. Two predators, *Dipha aphidivora* and *Micromus igorotus* were found feeding on woolly aphid.

Pyrilla (*Pyrilla perpusilla*): *Pyrilla* incidence was recorded from Dadh area.

Scale insect (*Melanaspis glomerata*): Incidence of scale insect was not found on major variety CoM 265 in the command area of Pravaranagar Sugar Mill. However, incidence of scale insect was observed (3 to 5%) on variety Co 86032. Its parasitoid *Adelencyrtus mayurai*, *Adelencyrtus moderatus* and *Botroideclava bharatiya* were active and managed pest.

White fly (*Aleurolobus barodensis*): White fly incidence observed on poorly managed plant and ratoon crop (8 to 20%).

Genetic diversity and transmission of pathogens causing yellow leaf disease (YLD) in sugarcane

Yellowing of the leaf-midrib and adjoining lamina along with irregular yellow patches were observed on CoLk 94184 and CoSe 92423. Association of a phytoplasma was confirmed by PCR (~1.8 Kb) and

nested PCR (~1.2 Kb) using phytoplasma specific primers. The *in silico* sequence analyses confirmed the association of '*Candidatus Phytoplasma asteris* (16SrI-B) subgroup phytoplasma with yellow leaf disease of sugarcane for the first time in India. Association of the sugarcane yellow leaf phytoplasma (SCYLP) was also observed in Co 0238 and Co 7717 by PCR (~1.8 kb) and nested PCR amplification (~1.2 kb) using phytoplasma- specific primers.

Evaluation/screening of sugarcane genotypes against red rot and smut

A total of 211 genotypes were screened against red rot (CF 08 and CF 09) and smut. Natural incidence of wilt, leaf scald and grassy shoot disease (GSD) was also recorded.

Red rot: Out of 211 genotypes tested, 139 genotypes were resistant (MR) and 57 genotypes exhibited moderately susceptible (MS) to highly susceptible (HS) reaction to both the pathotypes (CF 08 and CF 09) of red rot pathogen. Four genotypes, *viz.,* LG 09070, LG 97022, LG 10435 and LG 01009 were moderately susceptible (MS) to susceptible (S) to CF 08 while moderately resistant (MR) to CF 09. Eleven genotypes, *viz*., LG 05434, LG 07595, LG 08456, LG 08477, LG 08478, LG 09072, LG 09471, LG 10433, LG 10460, LG 10470 and LG 95123 were moderately susceptible (MS) to susceptible (S) to CF 09, whereas, all the genotypes were moderately resistant (MR) to CF 08.

Smut: Out of 211 genotypes tested, 49 genotypes were found to be susceptible and remaining 162 were tolerant to smut.

Wilt: Sixty six genotypes were found susceptible to highly susceptible to wilt and rest 145 genotypes showed field tolerance.

Leaf scald: Natural incidence of leaf scald was observed in LG 08478, LG 011612 and LG 011638.

Grassy shoot disease (GSD): Grassy shoot disease was observed in LG 10736 and LG 11606.

Enhancing efficacy of *Trichoderma*-based red rot management system

Studies were carried out to isolate and characterize *Trichoderma* sp. from sugarcane agro-ecosystem and to assess the role of various enzymes/secondary metabolites produced by *Trichoderma*, in the inhibition of *Colletotrichum falcatum*. A total of 126 *Trichoderma* isolates were established, characterized and maintained in laboratory for further studies. Fifty isolates were screened for production of chitinase and cellulase. Chitinase production was observed in 17 *Trichoderma* isolates; with 9 isolates having high chitinase activity and 8 low chitinase activity. Cellulase production was observed in only seven isolates with enzymatic index ranging from 1.41 to 1.91. Two *Trichoderma* isolates, *viz*., STr-83 and 108 showed high level of activity for both chitinase (85.49 and 87.17 µmoles NAGA released/min/mg protein in STr-83 and 108, respectively) and cellulase (320.18 and 316.20 µmoles glucose released/min/mg protein in STr-83 and STr-108, respectively).

Culture filtrates produced by different *Trichoderma* isolates were evaluated against *C. falcatum* and their impact on various biochemical parameters was assessed. The highest inhibition of *C. falcatum* growth *in vitro* was recorded with culture filtrate of isolate STr-121 (76%). In field experiment, the highest reduction in bud mortality as compared to control was observed in treatment with culture filtrate of isolate STr-108 (55.1%). STr-108 and STr-12 treated plants showed the highest protein contents, *viz*., 13.68 mg/g and 11.36 mg/g, respectively. The highest phenylalanine ammonia lyase (PAL) activity were 0.30 and 0.11 µmoles/min/mg protein in STr-96 and STr-108, respectively. The maximum phenol content was recorded in STr-108 (0.37 mg/g) followed by STr-52 (0.30 mg/g) and STr-12 (0.27 mg/g). Culture filtrate of isolate STr-108 was subjected to solvent extraction using hexane and ethyl acetate and concentrate was evaluated against *C. falcatum in vitro*. Formation of inhibition zone was observed in the concentrate obtained using ethyl acetate.

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

A field trial was conducted to evaluate two delivery methods of *Trichoderma* through conventional @ 220 kg/ha and spaced transplanting technique (STP) @ 2 g/plant (CoLk 94184). Observations on germination, quality parameters were recorded. The settlings raised by STP gave a significantly higher cane yield when treated with *Trichoderma* as compared to untreated control, whereas, in conventional method of planting with *Trichoderma*, increase in cane yield was non-significant.

Shelf-life studies of *T. harzianum* on sorghum grains and bagasse were carried out at room temperature. Population density of *T. harzianum* after one month was $2.3x10^8$ cfu/g on sorghum grains, whereas, it was 2.0×10^8 cfu/g on bagasse. The population of *T. harzianum* remained almost stable on both the substrates for a period of two months. After

five months, a decline in population of *T. harzianum, i.e.,* 7.5×10^6 cfu/g on sorghum grains and 5.0×10^6 cfu/g on baggase was recorded.

Identification of pathotypes in red rot pathogen

This year, 13 new isolates, including six isolates from CoLk 8102 (IR-60, IR-61, IR-62, IR-63, IR-64 and IR-65); three isolates from CoS 767 (IR-66, IR-67and IR-68), one isolate each from CoSe 92423 (IR 69); CoS 91269 (IR-70); CoSe 95422 (IR-71) and CoS 8436 (IR-72) 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, indicating no emergence of any new virulent pathotype in this zone.

Evaluation of zonal varieties against red rot, smut and wilt

North West Zone (IISR, Lucknow): During 2014-15, thirty eight genotypes were evaluated against red rot, smut and wilt. Natural incidence of yellow leaf disease (YLD) was also observed. Three genotypes, *viz.,* CoH 11261, CoH 09263 and CoPb 10182 were susceptible (S) to highly susceptible (HS) to both the pathotypes (CF 08 and CF 09) of red rot. Two genotypes, CoPb 11182 and CoPb 09214 showed susceptible reaction to one pathotype and resistant to other. The remaining 33 genotypes showed moderately resistant (MR) reaction to both the test pathotypes.

Thirteen genotypes, *viz.,* CoLk 11203, CoLk 11204, CoLk 11205, CoH 09263, CoH 10262, Co 11027, CoPb 09214, CoPb 10182, CoPb 11181, CoPb 11213, CoPb 11214, CoS 09232 and CoS 11232 were susceptible and rest 25 genotypes were tolerant to smut. Natural incidence of wilt was observed in nine genotypes *viz.,* CoH 09264, CoH 11262, CoLk 11201, CoPb 11182, CoPb 11212, Co 10035, Co 10036, Co 11026 and CoS 09246. Yellow leaf disease (YLD) incidence was also observed in CoPb 010181, Co 11027 and CoS11231.

North Central Zone (IISR-RC, Motipur, Bihar): In North Central Zone, 20 genotypes were screened against red rot. CoP 11437 was moderately susceptible to CF 07 and CF 08. CoSe 11455 was moderately susceptible (MS) to CF 07 and moderately resistant (MR) to CF 08. Eighteen genotypes exhibited resistant (R) to moderately resistant (MR) reaction to both the pathotypes. Among the standard checks, CoP 9301 was moderately resistant and BO 91, CoSe 92423 and CoSe 95422 were moderately susceptible (MS) to susceptible (S) to both the test pathotypes.

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

Twelve midlate maturing sugarcane genotypes including standard checks CoH 09264, CoH 10262, CoPant 10221, CoPb 09214, CoPb 10181, Co 09022, Co 10036, CoLk 09204, CoS 09232, CoS 767 and CoPant 97222 were evaluated for their reaction against insect-pests of sugarcane. Three genotypes (CoPant 10221, CoPb 10181 and Co 09022) were LS (less susceptible) and remaining genotypes were MS (moderately susceptible) to top borer (III brood). All the genotypes were less susceptible (LS) to stalk borer.

In early group, nine genotypes including standard checks Co 10035, CoH 09262, CoH 09263, CoH 10271, CoLk 09202, CoPb 09181, CoS 09246, CoS 10231 and CoJ 64 were evaluated for their reaction against insect-pests of sugarcane. CoH 09263 and CoS 09246 were LS to top borer. Whereas, the genotypes, Co 10035, CoH 10261 and CoS 10231 were LS to internode borer. All the genotypes except CoH 09262 were LS to stalk borer.

On cane basis, cent per cent infestation of mealy bug was recorded in all the genotypes. Incidence of black bug (*Dimorphopterus gibbus*) was higher in those genotypes having loosely attached leaf sheath. Incidence of *Pyrilla* was observed in all the genotypes but infestation was more severe in genotypes having broader leaf lamina. Cocoons of *Epiricania melanoleuca* were observed on leaves, as a result, low incidence of *Pyrilla perpusilla* was recorded in the month of October. Prasitisation of top borer larvae by *Rhaconotus* sp., *Stenobracon* spp., *Isotima javensis* was also observed. Amongst predatory fauna, coccinellid beetles, spiders and green lace wing were the prominent ones.

Monitoring of insect-pests and bioagents in sugarcane agro-ecosystem

Data on germination, incidence of insect-pests and parasitoids of pests were recorded in the variety CoLk 8102. Germination was 37.50%. Incidence of termites varied from 9.09 to 29.41%, while, after cane formation, damage of termites was limited to dry leaves only. Incidence of top borer II, III and IV brood was 2.35-8.33, 10.30-33.68 and 22.78-38.67%, respectively. Incidence of root borer at shoot stage was 6.67-8.0% and in the month of September, incidence was 25.0-66.67%. Incidence of internode borer was 9.85 to 20.45%. Stalk borer incidence was >5.0%. The incidence of *Pyrilla* was very high which was subsequently suppressed by its parasite, *Epiricania*

melanoleuca. Incidence of mealy bug was 100%. Whitefly, black bug were in traces. Other parasites, like *Telenomus beneficiens*, *Stenobracon* sp., *Rhaconotus* sp., *Isotima javensis* and predatory fauna comprising of coccinellids, spiders and ants were also noticed in the field at different stages of the crop.

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

Chrysoperla carnea is a well-known predatory insect. Grubs feed on soft bodied insects, eggs and newly emerged borer larvae. Work on rearing of *C. carnea* was carried out. Adult of the insect was collected from sugarcane field during post-monsoon months. Male and female insects were collected and released in glass jar. Females laid eggs on glass surface and at black head stage, eggs were separated by cutting their stalks and transferred to glass vials containing freshly laid eggs of *Corcyra cephalonica* (rice moth). These were kept at 27°C in BOD incubator for further embryonic development. Newly hatched grubs fed on *C. cephalonica* eggs. Larval (grub) stage was 14-19 days and adult insects emerged from the pupae in 3-4 days. Adults were allowed to feed on 50% honey solution. Various protein rich diet combinations were also tried to induce egg laying, and found that single female laid 400 to 600 eggs. For the development of grubs, animal protein based diets were tried alone or in combinations on which grubs completed their different life stage successfully and converted to pupae. For mass rearing of the insect, plastic cages, glass jars and multiwell plates were used. Egg, grub, pupal and adult period was 3-4, 14-19, 6-7 and 15-20 days, respectively when multiplied on artificial diets.

Management of borer complex of sugarcane through lures

An experiment was conducted in one acre sugarcane field. In half of the area, Six different pheromone traps at 20 meter apart were placed. Moth catches were recorded on daily basis. Total number of male moths of top borer (II brood) caught in traps were 451 (75/trap). Total catch of top borer moth (III brood) were 532 (89/trap). Incidence of top borer (II brood) in plot with traps ranged from 0-2.5% as against 0-3.66% in plants without traps. Incidence of top borer (III brood) in plots with traps and without traps were 11.76-35.0% and 13.75-36.0%, respectively. No catches of top borer (IV brood) were observed due to continuous rains in rainy season.

Mechanism of resistance against top borer of sugarcane

Nine sugarcane varieties, *viz.*, CoS 94257, CoS 96268, CoS 767, CoSe 92423, CoPant 97222, Co 0238, CoLk 8102, CoLk 94184 and CoJ 64 were studied for a possible correlation between plant characters and top borer incidence. 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). All the varieties except CoLk 8102 showed low incidence (1.74-6.60%) of top borer. Incidence of top borer in CoLk 8102 was 15.56%. However, no correlation recorded with physical characters of the test varieties and resistance to top borer.

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

For multiplication of larval parasitoids of top borer damaged shoots were collected from field and stored. Sugarcane stalk pieces (3-4 inches) were split longitudinally into two equal halves and a central tunnel was made. One or two vertical holes (1.5 mm diameter) were drilled from the rind towards the tunnel. Stored top borer larvae were placed in the tunnel (one per tunnel) and wrapped with parafilm to prevent escape of larvae and kept in glass jars covered with muslin cloth. In each jar, one pair of *Isotima javensis* (after 24 h emergence) was placed. The parasitisation of top borer larvae by *I. javensis* was 33.56%. A male biased sex ratio was recorded.

Containment of major insect-pests of sugarcane through habitat modifications

To contain the insect-pests through habitat modifications, crops grown in the sugarcane agro-ecosystem like coriander, mustard, marigold, tomato, brinjal, jowar, maize were taken to study the push-pull effect. The incidence of top borer (I brood) ranged from 3.24-9.23% along with various trap crops in comparison to control (12.21%). The minimum incidence of I brood was observed in plots along with coriander (3.24%), marigold (5.30%), mustard (5.49%), brinjal (8.66%) and tomato (9.23%). The minimum incidence of II brood was observed in plots along with coriander (2.86%) in comparison to control (15.15%). The parasitisation of eggs of top borer by *Trichogramma chilonis* and *Telenomu*s sp. ranged from 15.21-24.95% along with marigold, coriander and maize. The incidence of III brood of top borer was lower along with various trap crops (9.63-

10.94%) as compared to control (17.41%). The minimum incidence of IV brood (12.94%) was observed in plots along with jowar in comparison to control (22.56%). The incidence of top borer (V brood) ranged from 8.11 to 16.10% in plots along with maize, tomato and jowar as compared to 19.61% in control. The parasitisation of top borer larvae (III and IV brood) by *Rhaconotus scirpophagae, Isotima javensis* and *Stenobracon nicevillei* ranged from 32.86 to 49.62% and 36.87 to 48.40% along with various trap crops, whereas, it was 22.89-24.84% in control.

Semio-chemicals for the management of sugarcane top borer

A field experiment was conducted with three top borer susceptible varieties (CoLk 8102, Co 0238 and CoJ 64). Field collected top borer larvae were crushed in water for preparing spray solution. Spray was maintained @ one larvae/litre of water. Foliar spray was done in June. Effect of crushed top borer on parasitization by larval/pre pupal parasites and incidence of top borer (IV brood) was studied. The incidence of top borer and egg parasitization in different varieties was as recorded.

In CoLk 8102, the incidence of top borer in plots treated with egg wash was 15.54% and egg parasitisation was 4.44%; in plots treated with larvae crush was 16.58% and larval parasitisation was 14.44%; in plots treated with pupal wash was 22.40% and larval parasitisation was 10.0%, while in untreated control, it was 15.64% and no parasitisation was observed.

In Co 0238, the incidence of top borer in plots treated with egg wash was 12.22% and egg parasitisation was 4.44%; in plots treated with larvae crush was 17.93% and larval parasitisation was 12.22%; in plots treated with pupal wash was 14.27% and larval parasitisation was 5.56%, while in untreated control, it was 16.8% and no parasitisation was observed.

In CoJ 64, the incidence of top borer in plots treated with egg wash was 7.57% and egg parasitisation was 3.33%; in plots treated with larvae crush was 14.02% and larval parasitisation was 7.78%.; incidence of top borer in plots treated with pupal wash was 9.97% and larval parasitisation was 4.45%, while in untreated control, it was 9.70% and larval parasitisation was 3.33%.

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

Mass multiplication and field colonization of *Trichogramma chilonis* against sugarcane borers were carried out in different villages around Pravaranagar. Details of release are given in Table 5.4. A total of 1, 66, 80,000 adults of *Trichogramma* sp. were released in 1112 acre of sugarcane crop of 297 farmers against early shoot borer from April 2014 to March 2015.

Table 5.4. Field colonization of *Trichogramma* sp. against early shoot borers

Month	Number of adults released	Number of farmers benefitted	Area (acre)
April	1470000	22	98
May	1245000	25	83
June	1215000	19	81
July	1335000	20	89
August	1485000	23	99
September	1470000	25	98
October	1170000	24	78
November	1185000	30	79
December	1485000	27	99
January	1620000	22	108
February	1545000	31	103
March	1455000	29	97
Total	**16680000**	**297**	**1112**

Efficacy of *Trichogramma chilonis* against early shoot borer (*Chilo infuscatellus*)

Efficacy of *Trichogramma chilonis* against early shoot borer were studied on plant and ratoon crops. Release of *Trichogramma chilonis* was started after one month of planting/ratooning. Laboratory bred *Trichogramma chilonis*@ 50,000/ha at 10 days interval was released against early shoot borer from August to October. Observations on incidence were recorded at fortnight interval (Table 5.5). Data indicated that the incidence of shoot borer in plant and ratoon crops was 0.36 to 1.35% and 0.45 to 1.21% in *T. chilonis* was released plots as against 1.0 to 2.43% and 0.88 to 2.1% in unreleased fields.

Laboratory bred *T. chilonis* @ 50,000/ha at 10 days interval was released against early shoot borer from January to March (Table 5.5). Data revealed that in *T. chilonis* released and unreleased fields; per cent incidence was 0.96 to 2.48% and 2.13 to13.20% in plant and 1.0 to 2.15% and 2.38 to 13.55% in ratoon crops, respectively. In general, incidence of early shoot borer was at low level during both the seasons. However, response of release of *T. chilonis* was found better in all types of crops comparatively in unreleased fields.

Table 5.5. Effect of *T. chilonis* on early shoot borer during August to October and January to March

Month	Fort-night	Incidence of early shoot borer (%)					
		Plant crop		Ratoon crop		Single bud crop	
		Released	Unreleased	Released	Unreleased	Released	Unreleased
August	I	0.36	1.0	0.45	0.88	0.95	1.21
	II	0.63	1.45	0.70	1.08	1.00	1.40
September	I	0.98	1.73	0.78	1.28	1.41	1.55
	II	1.11	2.11	0.91	1.48	2.10	1.83
October	I	1.21	2.25	1.00	1.56	1.88	2.28
	II	1.35	2.43	1.21	2.10	2.15	2.66
January	I	0.96	2.13	1.00	2.38	0.70	2.16
	II	1.25	3.03	1.48	3.31	1.16	2.48
February	I	1.40	7.16	1.56	5.21	1.60	3.00
	II	1.83	13.20	1.70	8.16	1.90	5.33
March	I	2.48	9.73	2.15	13.55	2.65	8.25
	II	2.23	7.00	1.86	8.5	2.16	5.83

Colonization and redistribution of *Zygogramma bicolorata* against *Parthenium* weed

Beetles of *Zygogramma bicolorata* were reared in laboratory and released against *Parthenium* weeds. It was observed that beetles were found feeding on *Parthenium* weeds from July to October in villages, Chinchpur, Kolhar, Fattyabad, Rahuri, Mamdapur, Babhaleshwar, Cincholi, Tisgaon, Belapur, Lakpadegaon and Pravaranagar.

5

Basic research in physiology and biochemistry

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

For improving sucrose content in cane stalk, foliar application of enzyme effectors containing Mg + Mn + ethrel @ 10 mM, 5 mM and 100 ppm, respectively was performed at the start of ripening phase in autumn, spring planted and ratoon crop of variety CoLk 94184 (an early maturing variety) and spring planted variety BO 91 (a midlate maturing variety). Both the varieties endicated an increase in the juice quality attributes, like sucrose % juice, Brix, juice purity and S/R ratio. Increase in sucrose was the highest in ratoon crop (18.22% in treated vs 16.05% in control) in variety CoLk 94184 and spring planted variety BO 91 where sucrose was 13.18% in treated compared to 9.91% in control.

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

About 200 RNA samples have been isolated from source and sink tissues under control and source-sink perturbed conditions in two varieties of sugarcane and at different periods of time. GA_3 perturbed cane and leaf have been used to isolate the total RNA for RT-PCR. These RNAs were checked and equilibrated having RT-PCR done with 25S Ribosomal RNA gene (reference gene). Profiling of the different internodes with respect to total and reducing sugars were made using varieties CoLk 94184, BO 91 and CoJ 64.

Minimizing post-harvest sucrose deterioration and its molecular assessment

Studies were carried out using potent bactericidal and anti-inversion chemicals indicated that BKC being bactericidal showed better response in terms of brix, reducing sugar and total sugar in cane juice. Concentration of 1000-2000 ppm BKC was found to be the most suitable checking the juice quality deterioration (Fig. 5.1). RNA isolated at different stages are being used to carry out the real-time PCR.

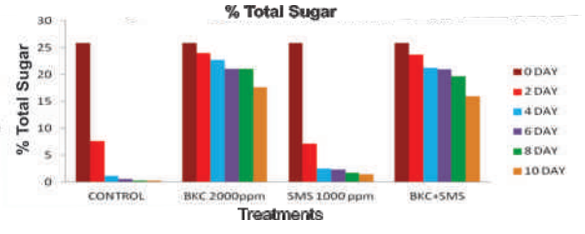


Fig. 5.1. Change in total sugar (%) in cane juice isolated at different dates of stale cane and impact of BKC and SMS.

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

Three bud setts of 20 sugarcane genotypes including five commercial cultivars, *viz*., CoLk 94184, BO 91, CoS 767, CoJ 64, CoS 97264 five IVT genotypes, CoLk 12204, CoLk 12202, CoLk 12206, CoLk 07201, CoLk 04238, five station trial genotypes LG 06605, LG 04439, LG 05350, LG05020, LG03040, and five C-2 stage genotypes A-46-11, B-44-12, A-27-12 (old 22), D-12-9, D-6-13 were planted at Kharika Farm, IISR, Lucknow during spring season in two different plots, control and water-logged (deep plot filled with rain water during monsoon season). Results indicated that

Fig. 5.2. Aerial rooting in waterlogged plants

almost all the genotypes exhibited aerial rooting (Fig. 5.2), crop lodging, leaf chlorosis, reduced number of tillers due to waterlogging stress. Nitrate reductase *in vivo* activity was reduced under waterlogged condition in all the genotypes except CoLk 07201, LG 06605 and D-12-9. Waterlogging stress reduced SPAD reading (non-destructive estimation of chlorophyll) in most of the genotypes except CoLk 94184, BO 91, CoS 767, LG 04439, LG05020. Waterlogging affected plants exhibited higher activity of peroxidase enzyme in almost all genotypes except in CoJ 64 and CoLk 12204. Specific leaf weight (SLW) ranged between 7.77×10^{-3} to 12.6×10^{-3} among different sugarcane genotypes under waterlogged condition; the highest being recorded in CoS 767 and the lowest in CoLk 12202. In contrast to SLW, genotype, CoS 767 exhibited the lowest specific leaf area (SLA). Juice quality attributes, *viz*., °Brix, sucrose percent and juice purity increased due to waterlogging condition; only a few genotypes showed a slight decrease over the control. Alcohol dehydrogenase (ADH) activity ranged from 0.02 to 0.089 OD/mg/min.

6

Mechanization of sugarcane farming

Development of deep furrow sugarcane planter

Tractor operated PTO driven sugarcane planter was developed with modified deep furrow opener (20-25 cm) which maintains loose soil bed at the bottom of the furrow. The designed planter (deep furrow sugarcane planter) consisted of main frame with three point linkage, sett cutting and fertilizer metering unit, power transmission unit for transmitting tractor PTO power to the sett cutting and fertilizer metering units, insecticide solution application unit, soil covering and tamping unit. Planter was fabricated and field tested (Fig. 6.1).

Fig. 6.1. Tractor operated deep furrow sugarcane planter

It performs all the unit operations involved in sugarcane planting, *viz*., furrow opening, sett cutting, sett placement in furrows, fertilizer and insecticide application(s), soil covering over setts and its tamping, simultaneously in a single pass of the planter. It maintains loose soil bed (2.5-4.0 cm) underneath the planted setts. Large-scale field trials of the planter were conducted at farmers' field of Muzaffarnagar district. The effective field capacity of the equipment was 0.2 ha/h.

Modification of paired-row trench planter

The IISR paired-row trench planter was modified and the power transmission and fertilizer application units were redesigned and modified (Fig. 6.2). This model was developed to facilitate wide-spaced paired-row planting of sugarcane in deep and wide trenches. A trench of about 20-25 cm deep is made by this planter. Two rows of cane, 30 cm apart, are placed at the bottom of the trench and fertilizer and insecticide are also dispensed.

Fig. 6.2. Modified sugarcane trench planter

Provision for laying of sub-surface drip laterals is also there. All the above operations are carried out in a single pass. It covers one hectare in approximately five hours.

Development of tractor operated sugarcane manager

Prototype of tractor operated sugarcane manager with seed drill attachment was developed. It performs inter-culturing and fertilizer application in standing cane crop. It also facilitates sowing of inter-crop in sugarcane ratoon field. The prototype was tested in the field (Fig. 6.3).

Fig. 6.3. Tractor operated sugarcane manager with fertilizer application and sowing arrangements

The effective field capacity of the equipment is 0.4 ha/h. The prototype was demonstrated in the presence of the Director General, ICAR, New Delhi, and Deputy Director General (Crop Science), ICAR, New Delhi, and other dignitaries visiting the Institute.

Design refinement of tractor operated sugarcane-cum-potato planter

Prototype of tractor operated sugarcane-cum-potato planter (Fig. 6.4) was fabricated and tested in the laboratory. Modified metering mechanism is working well for picking the cut potato seeds. The prototype was tested in the field and demonstrated to the Director General, ICAR and Deputy Director General (Crop Science) and other dignitaries visiting the Institute. Test results revealed that there is need to reduce the size of the potato seed metering cups for uniform metering of seed potato.

Fig. 6.4. Modified tractor operated sugarcane-cum-potato planter

Development of tractor operated sugarcane harvester for small farms

Tractor operated rear mounted sugarcane harvester was designed and fabricated. It consisted of main frame, rotary cutting blades for basal cutting of sugarcane, power transmission system for transmitting the tractor PTO power to the cutting blades and stationery guiding frame (Fig. 6.5). It was tested in the field for cutting of single row of sugarcane stalks. Cutting performance of blades were satisfactory. The lodged canes which were out of range of cutting blades were left unharvested and required to be harvested manually. Detrashing of sugarcane to be performed separately either manually or by feeding into detrasher. The limiting factor of this model was non-harvesting and bruising of lodged canes.

Fig. 6.5. Tractor operated rear mounted sugarcane harvester

AICRP on FIM

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

Prototypes fabricated

Particular	Nos.
Tractor operated (T.O.) sugarcane planter (PTO driven)	1
T.O. sugarcane planter (Ground wheel driven)	3
Conservation tillage equipment	1
T.O. paired row (30 cm spacing) trencher	2
T.O. paired row (45 cm spacing) trencher	1
T.O. paired row (30 cm spacing) trench planter	1
T.O. paired row (45 cm spacing) trench planter	1
T.O. ratoon management device with discs	2
T.O. sugarcane manager II unit	1
T.O. sugarcane manager with seed drill	1
T.O. sugarcane planter with adjustable row spacing of 75/90 cm (PTO driven)	1
Total	**15**

Frontline demonstration of IISR tractor operated ratoon management device (RMD)

IISR tractor operated ratoon management device (RMD) is used for stubble shaving, off-barring, interculturing (deep tilling), fertilizer as well as manure dispensing and earthing up in sugarcane ratoon crop. Frontline demonstration of this equipment was conducted at farmers' fields in Biswa Sugar Mill area of Sitapur district in 8.0 ha area. It covers two rows spaced at 75 cm in single pass. Effective field capacity of the equipment is 0.3 ha/h.

Frontline demonstration of IISR modified three row cane planter

Frontline demonstrations of IISR tractor operated modified three row sugarcane planter was conducted at farmers' fields in Lakhimpur Kheri district of U.P. in 3.0 ha area. Effective field capacity of the planter is 0.25 ha/h. Cost of planting was reduced by 60% 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 of Lucknow in 2.4 ha area. About 6.0 ha

Prototypes supplied

Name of equipment	Quantity	Supplied to
Manufactured and supplied by IISR Lucknow		
T.O. ratoon management device with discs	1	ARS, KAU, Kallankal, Thiruvalla
T.O. paired row (30 cm spacing) trencher	1	U.P. Agro Industrial Corporation Ltd., Varanasi, U.P.
T.O ground wheel driven three row sugarcane cutter planter	1	Ram Dhani Verma, Village Akavara, Faizabad, U.P.
Manufactured and supplied by MGS Agriculture, Deva Road, Lucknow		
T.O. paired row (45 cm spacing) trencher	150	Harinagar Sugar Mill, Harinagar, Bihar
T.O. paired row sugarcane trench planter	1	Muzaffarpur, Bihar

area was also planted with this equipment at IISR farm. 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 is 0.20 ha/h. Cost of planting was reduced by 60% as compared to conventional method of planting.

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 × 203 mm) was fabricated and tested. During testing, it was felt that providing simple holes on the device does not work well. These holes failed to direct flames towards the pan bottom. Hence, in all 21 holes provided on the efficiency boosting device, nipples of 10 mm length and 4 mm diameter were provided. These nipples will direct flames towards the pan bottom more effectively.

Evaluation of jaggery furnace (single, double and triple pan) for emission of greenhouse gases and level of bagasse combustion

IISR 2-pan furnace was tested for emission of carbon monoxide (CO), carbon dioxide (CO_2), oxygen (O_2) and combustion efficiency and the values were recorded using flue gas analyzer. Fluctuations in values of above parameters; CO: 1000-2200 ppm, CO_2: 12-20%, O_2: 8-20% and combustion efficiency: 55-78% were observed. The temperature of flue gas touched the maximum value of 301°C. This temperature was found to be higher than the temperature of flue gas in case of 3-pan furnace tested earlier. Higher temperature of flue gas indicates that less amount of energy is being utilized as this furnace has only two pans and no energy is being used by the 3rd pan as in case of 3-pan furnace.

Refinement of juice extraction process with special reference to sugarcane cleaning and juice filtration

A cleaning-cum-washing machine for sugarcane was developed (Fig. 7.1). Six rollers of 20 cm diameter in three sets of two each have been provided for cleaning and scrapping and a gear box for speed reduction. This was tested at average rpm of 15. Speed of feed rollers was reduced for proper input and output. The unit was tested with 3-cane feeding,which partially scraped left out trashes, roots and soil clods. Therefore, scrubbing unit needs to be refined.

Development of hand operated sugarcane scrapper-cum-cutter

A manual sugarcane scrapper-cum-cutter

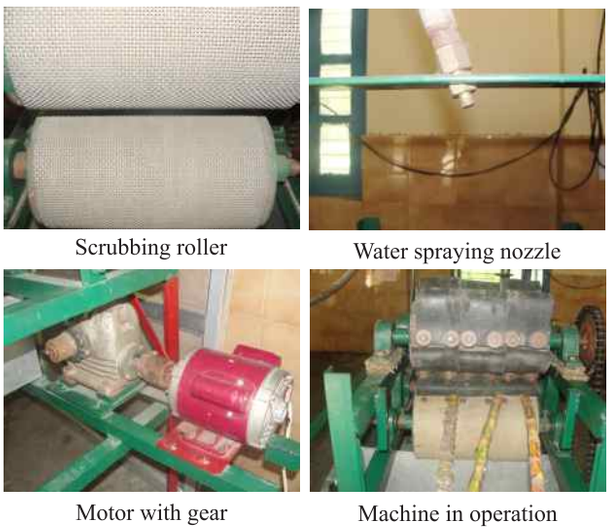


Fig. 7.1. Sugarcane cleaning-cum- washing machine

was developed to clean and cut unwanted portion of sugarcane with less effort (Fig 7.2). This is very useful for juice vendors and is being used by the jaggery unit for supply of clean and fresh sugarcane juice at *Ikshu* Hub.

Fig. 7.2. Sugarcane scrapper-cum-cutter and cleaned canes after its use

Development/adoption of evaporator for sugarcane juice

Local fabricators have been contacted for fabrication of evaporator as per the design.

Simultaneously, some of the units have been visited to see suitability of their evaporators as per the requirement. It was felt that a mini boiler would be needed for working of evaporator for which possibility is being explored.

Evaluation of shrink wrap, stretch wrap and modified atmosphere packaging for storage of jaggery cubes and blocks

Jaggery blocks of size 30 cm × 23 cm × 7.5 cm weighing 5 kg each were purchased from local market and packed in shrink wrap and stretch wrap. These were also stored in hermetically sealed plastic container for a period of six months. It was found that after the storage period jaggery blocks packed in shrink and stretch wrap softened and therefore, could not sustain the storage period. However, jaggery block packed in hermetically sealed container showed superior texture and colour.

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 consisted of auger arrangement on main vertical shaft for downward movement of jaggery mass and horizontal blades with tilted tips for proper mixing. It was used with a stainless steel container for mixing.

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

Keeping in view the aroma, taste, medicinal value and suitability, different Indian spices were identified for value-addition (Table 7.1). Above materials were added in cooling pan while puddling of concentrated jaggery slurry. These were mixed thoroughly and moulded in pieces of 25 mm × 25 mm × 12.5 mm (10 g) using IISR jaggery moulding frame. After removal from frame, these were packed individually using butter paper and aluminium foil (Fig. 7.2). Following quantities were identified optimum based on organoleptic evaluation:

Fig. 7.2. Value-added jaggery with turmeric powder

Table 7.1. Materials and their quantities used for value-addition

Additive	Pre-addition preparation	Quantity (g/kg of jaggery)
Ginger	Drying, grinding	15, 20, 25, 30
Turmeric	Drying, grinding	10, 15, 20, 25
Caraway	Roasting	5, 10, 15, 20
Black pepper	Grinding	5, 10, 15, 20
Asafoetida	Roasting, grinding	0.5, 1.0, 1.5, 2.0
Sesame seed	Roasting	200, 300, 400
Nigella seed	---	10, 15, 20, 25

Table 7.2. Optimum quantity of materials identified

Additive	Quantity (g) for addition per kg of jaggery
Ginger	25
Turmeric	15
Caraway	10
Black pepper	15
Asafoetida	1.5
Sesame seed	400
Nigella seed	15

To assess acceptability of value-added jaggery these were sold at the rate of Rs. 2/piece (Rs. 200/kg). Wide acceptability was observed and huge demand for such kind of jaggery was generated.

Development of a semi-automatic jaggery manufacturing plant

All the processes has been identified where mechanical interventions can be made. The scum removal, concentrated jaggery removal from pan, cooling and mixing and moulding section could be mechanized. An electric suction assembly used in hospitals and vacuum cleaner will be suitably modified for removing the scum.

Development of power operated jaggery moulding machine

The power operated jaggery mounding machine was designed having one h.p. motor for upward and downward movement for pressing out

the jaggery cubes in the bottom plate. Arrangements were made for smooth action of the pressing assembly.

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

PET film with thickness of 95 µm and temperature of 20°C was found to be suitable for storing jaggery under humid conditions. The analysis was done using Design Expert 6.0 software. The design used in the analysis was Box-Behnkem under Response Surface Methodology (RSM). The jaggery could be safely stored for 135 days. With the increase in film thickness, all the parameters showed less variation with storage period. Whereas, with the increase in temperature and moisture content, mixed trend was recorded. But the colour, phenolic content and reducing sugar increased and hardness decreased with storage period.

Assessment of post-harvest losses in major crops and commodities in India

The survey was conducted for assessment of post-harvest losses in ten crops/commodities in five districts of Uttar Pradesh, *viz*., Chandauli, Deoria, Kanpur Dehat, Etawah and Unnao. Two blocks were taken from each selected district. Then five villages were taken from each block. Complete enumeration of all the selected villages was done as per survey proforma. After the enumeration, ten farmers from each village were selected as per guidelines provided for conducting the survey and farm level data collection. Data were collected by enquiry as well as by actual observation for assessment of losses at farmer/market/processor/godown level. The collected data was fed in the software designed, developed and supplied by IASRI, New Delhi and given through Project Coordinator, AICRP on PHT for analysis. The area-wise data of crop production of the five selected districts for crop year 2012-13 and 2013-14 was collected and supplied. The data supplied to CIPHET, Ludhiana was verified and sent for analysis.

Study on determining storage losses in food grains in Food Corporation of India (FCI) and Central Warehousing Corporation (CWC) warehouses and to recommend norms for storage losses in efficient warehouses

A visit was made to FCI as well as CWC godowns at Raebareli, Basti and Dhamora (Rampur district) to study, familiarize and finalize the selection of stacks and chambers as per guidelines issued by Project Coordinator (PHT). Stacking of wheat and rice has been completed at all the godowns. Fortnightly observations are going on. One stack each from selected chambers has been liquidated after the completion of first quarter and liquidation of stacks after second quarter is in progress.

Transfer of technology including FLDs in collaboration with KVK-IISR

- Twenty IISR jaggery moulding frames for making one-inch jaggery cubes have been supplied to different users.
- Improved jaggery making technology has been demonstrated at two places in Kavardha, Kabirdham (Chhattisgarh).
- Technology of three-pan furnace for jaggery manufacturing has been successfully transferred to a farmer in village Devrayee, Kerakat (Jaunpur).
- Trainings and demonstrations were conducted during current season informally (about 10) to different group of farmers/cane growers and also sugarcane development officers of sugar factories of U.P., Uttarakhand and Bihar.
- Technical guidance was given to jaggery manufacturer of Farrukhabad (U.P.).
- A three-pan furnace plant (IISR model) has been established at Talwara, Hoshiarpur in Punjab. The unit is working satisfactory. A steam based two-pan jaggery unit was also established at Talwara under technical guidance of IISR.

8

Information and communication technology

Development of data mining and presentation tools in sugarcane

Integrated studies of data captured from different domains require development of relationship among them. Database technologies provide mechanism of incorporating keys for setting relationship among data and also uniqueness of data. Partial structure of database has been developed for storing data collected so far. Primary keys have been incorporated to maintain uniqueness of data and setting relationship for further integrated studies. Since, data on sugarcane cultivation varies with respect to growing places, basic information about districts of India has been added in the database along with incorporation of PlaceCode as Primary Key. Primary key will act as key for setting relationship among variety of data loaded in the database from different domains for integrated studies. Further, the role of this key will be to search data from the repository for analytical studies of the same.

Literature was reviewed to collect temporal and spatial data on various aspects of sugarcane production. Variety of data collected and loaded in the database is as follows:

- Geographical reference points of Indian districts (places) in the form of latitude and longitude.
- Places are also marked with their Agro-Climatic region as identified by the Planning Commission.
- Land use pattern data of places has been collected and loaded in the database for 468 districts of the country.
- Data on rainfall pattern for 421 districts of India containing annual/seasonal rainfall and number of rainy days has been collected and uploaded.
- State-wise data of sugarcane area, production and productivity has also been loaded in the database and relationship with places have been made using PlaceCode.

Estimation of optimum sample size for evaluation and prediction of cross-performance

In order to optimize the seedlings required in a breeding program, estimation of an optimum sample size was made with the help of software developed for the same. Data of cane length, number of millable canes, individual cane weight, cane diameter, internode length and HR Brix for 2018 seedlings corresponding to 7 crosses was analysed using the software to find out the optimum sample size. Sample size was estimated for different margin of errors (1, 2, 10%) with confidence coefficients of 90, 95 and 99%. It was estimated that 150 seedlings are required with 8% permissible margin of error at 95% confident coefficient for evaluation of performance of a cross with respect to individual cane weight. Estimated sample size required for different values of margin of error and confidence coefficient with respect to seedling characters undertaken (Table 8.1). Breeders can use the table to find out optimum sample size for breeding trials depending upon the character, margin of error and confidence coefficient.

Geographical information system (GIS) of sugar and sugarcane producing countries with special reference to India

An attempt was made to understand the sugar production, consumption and trade in different countries. Database of sugarcane and sugar producing countries by sugarcane and sugarbeet (2013) was created and mapped with the help of Geographical Information System. Estimate shows that sugarcane is cultivated worldwide and 80.14% of total sugar is produced from cane only, while, remaining 19.86% sugar is derived from sugarbeet mainly grown in 23 countries of temperate zone. Out of 101 sugarcane producing countries (Map 1), top ten countries contribute 81.47% in area and 82.85% in production of the world.

Asian and South American countries (Map 2) dominate in sugarcane production which accounts for nearly 85% of cane production in world. Brazil and India are two major countries that have a large share in area (56.16%) as well as production (57.56%). Among the top ten countries, Colombia has the highest cane yield (86.0 t/ha) and rest of nine countries has cane yield in between 67 to 80 t/ha. Countries having high productivity (t/ha) of sugarcane (Map 3) are Peru (133.72), Ethiopia (119.57), Egypt (115.33), Senegal (114.10), Malawi (107.41), Zambia (102.56), Burkina Faso (102.13), Guatemala (100.69), United Republic of Tanzania (100.00) and Nicaragua (98.18) but these

Table 8.1. Number of samples required

Trait*	Number of total seedlings	Pooled seedlings CV (%)	Margin of error (*c*)									
			0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.10
Confidence coefficient = 90%												
NMC	2018	57	1639	1049	656	430	298	217	164	128	102	84
SCW	2018	51	1566	937	561	359	246	177	133	104	83	68
IN LEN	2018	19	656	217	102	59	38	27	20	15	12	10
Cane diameter	2018	19	656	217	102	59	38	27	20	15	12	10
HR Brix	2018	21	747	259	124	72	46	32	24	18	15	12
Cane length	2018	25	917	348	171	100	65	46	34	26	21	17
Confidence coefficient = 95%												
NMC	2018	57	1747	1245	842	579	413	306	234	184	149	122
SCW	2018	51	1690	1136	735	492	345	253	192	150	121	99
IN LEN	2018	19	842	306	149	86	56	39	29	22	18	14
Cane diameter	2018	19	842	306	149	86	56	39	29	22	18	14
HR Brix	2018	21	941	362	179	105	68	48	35	27	22	17
Cane length	2018	25	1117	477	244	145	145	67	50	38	30	25
Confidence coefficient = 99%												
NMC	2018	57	1846	1470	1097	809	606	463	362	289	236	195
SCW	2018	51	1807	1376	985	704	516	388	301	239	193	159
IN LEN	2018	19	1097	463	236	140	92	65	48	37	29	24
Cane diameter	2018	19	1097	463	236	140	92	65	48	37	29	24
HR Brix	2018	21	1196	538	281	168	111	78	58	45	36	29
Cane length	2018	25	1359	686	376	230	154	109	81	63	50	41

*NMC : number of millable canes, SCW : Simple cane weight, IN LEN : internode length

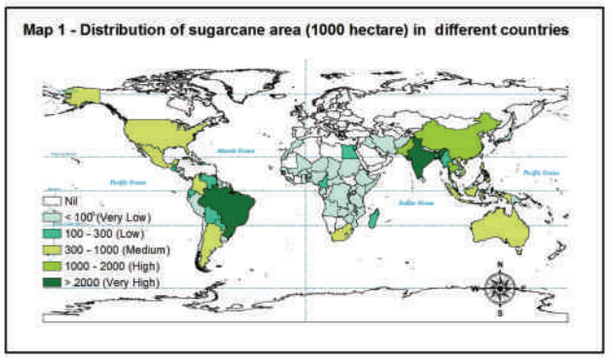
countries contribute only 2.59% in area and 3.97% in production of sugarcane in world, whereas, average cane yield of the world is estimated to be 70.8 t/ha (Table 8.2).

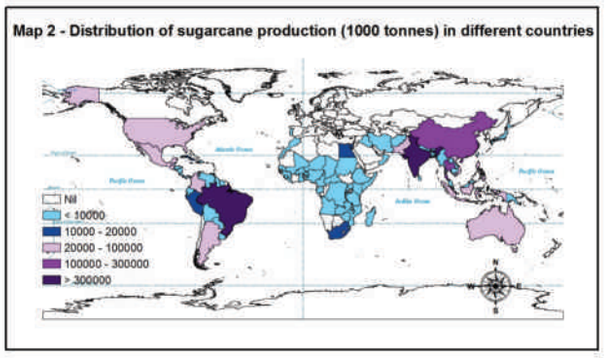
Out of 91 sugar producing countries (Map 4), the top ten sugar producing countries (from sugarcane) are Brazil (25.92%), India (19.73%), China (9.01%), Thailand (7.38%), Mexico (4.71%), Pakistan (3.37%), Australia (3.33%), USA (2.36%), Guatemala (2.02%) and Indonesia (1.81%) which account for 85% of sugar production from cane. However, 54% of world sugar is produced by five countries, *viz.*, Brazil (20.77%), India (15.81%), EU (9.46%) and China (7.72%). As far as export is concern, main sugar exporting countries are Brazil (44.23%), Thailand (15.84%), Australia (6.52%) and Guatemala (3.63%), which accounts for 70.77% of the total sugar export of the world. There are 127 sugar importing countries (Map 6), out of which, China (7.55%), Indonesia (7.55%), EU (6.96%), USA (6.26%), UAE (4.67%), South Korea (3.87%), Malaysia (3.83%), Bangladesh (3.78%), Algeria (3.68%) and Iran (3.18%) accounts for 51.33% of total sugar import of the world. Global sugar consumption has continued to increase from 1,62,438 k tonne (2010-11) to 1,76,834 k tonnes (2014-15). Major five sugar consuming countries are India (15.93%), EU (10.91%), China (9.01%), Brazil (6.78%) and USA (6.35%) which accounts for nearly 50% of total sugar consumption of the world.

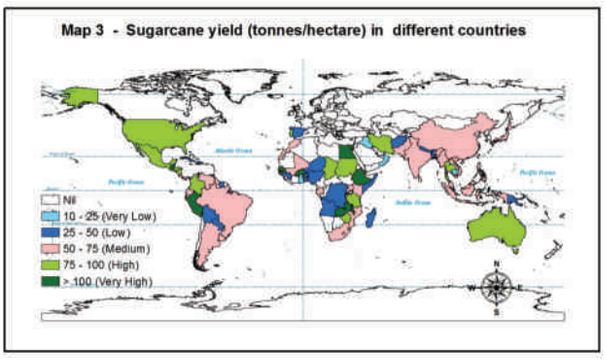
After increasing trend of world sugar production from 2010-11 (1,62,438 k tonne) to 2013-14 (1,81,404 k tonne), decline in sugar production was observed in 2014-15 (1,78,744 k tonne). As per an estimate, 35% of sugar produced globally is made available for trade by different countries. Most of the sugar produced by different countries are consumed internally by the large sugar producing countries like Brazil (20.77%), India (15.81%), EU-27 (9.46%), China (7.72%) and Thailand (5.92%). These five countries produced 60% sugar of the world and consumed around 45% of the world. Out of 69 sugar exporting countries of the world, Brazil (44.73%), Thailand (15.84%), Australia (6.52%), Guatemala (3.63%) and

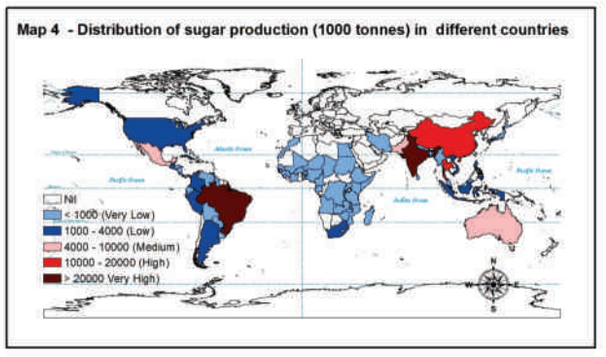
Table 8.2. Sugarcane area, production, yield and sugar production in different countries (2013)

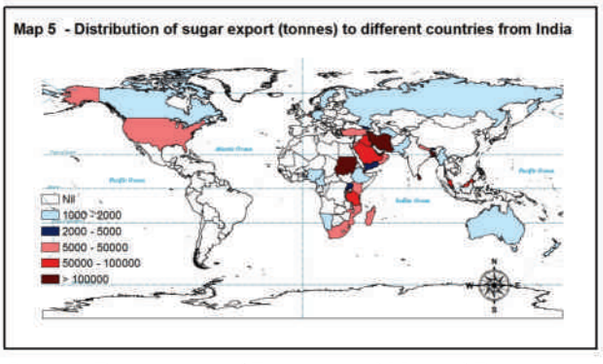
Country	Area (k ha)	Production (k tonne)	Yield (t/ha)	Sugar production (k tonne)
Brazil	9835.2	739267	75.2	35800
India	5060.0	341200	67.4	27250
China	1819.0	125536	69.0	13300
Thailand	1321.6	100096	75.7	10200
Pakistan	1128.8	63749	56.5	4700
Mexico	782.8	61182	78.2	6508
Indonesia	450.0	33700	74.9	2500
Phillippines	435.4	31874	73.2	2500
Colombia	405.7	34876	86.0	2300
Argentina	370.0	23700	64.1	2050
World	**26522.7**	**1877105**	**70.8**	**172363**

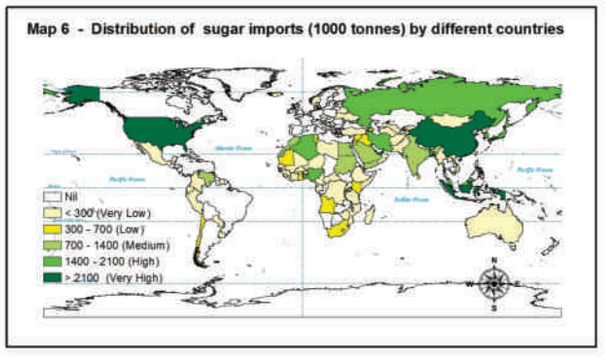












Source : Department of Forestry and Natural Resources, HNB Garhwal University, Srinagar (Garhwal), Uttarakhand

Mexico (3.32%) are major player in export of sugar which accounts for nearly 75% sugar export of the world.

Analysis of sugar production and consumption was also attempted using average of five years (2010-11 to 2014-2015) in different regions of the world. Analysis indicates that Asia is the largest producer (33.84%) as well as largest consumer of sugar (41.10%). There is a deficit of 7.27% requiring import of sugar to meet internal consumption in Asia. South America is the second largest producer (23.57%) of sugar, whereas, consumes only 11.07% sugar of the world and thus have 12.5% of surplus sugar to export. In case of North and Central America, sugar production and consumption are same (~11%) as the world average. Africa contributes only 5.70% of the world production, whereas, while consumes 9.91% sugar of the world and thus require to import sugar (4.21%). Similarly, European Union and Europe produces 23.56% sugar of the world and consume 26.34%. There is a deficit of 2.78% sugar to import from rest of the world. Oceania is the smallest producer (2.30%) and consumer (0.90%) of sugar and had surplus sugar (1.40%) to export.

Out of 91 sugar producing countries in world (Map 4), India is the second largest producer of sugarcane (18.18%) as well as sugar (15.81%) and is only next to Brazil. India is largest consumer of sugar (15.93%) and 7th largest exporter of sugar (2.80%) among 93 countries (Map 5). The large share of total export (1955 k tonnes) was made to Sudan (23.93%), Somalia (15.44%), UAE (10.74%), Sri Lanka (8.50%), Iran (5.95%), Saudi Arab (4.40%), Bangladesh (5.24%), Tanzania (4.02%), Djibouti (3.60%) and Iraq (3.24%) during 2014-15.

9

Transfer of technology

Demonstration of new sugarcane varieties in Muzaffarnagar (U.P.)

Demonstration of five varieties of sugarcane, *viz*., Co 0238, CoPK 05191, Co 0118, CoH 128 and Co 05011, recently released and notified for commercial cultivation in the North West Zone of the country, was undertaken on farmers' field in the Rasoolpur Jattan village of Muzaffarnagar (U.P.). The demonstrations are being conducted in 17 hectare area belonging to about 50 farmers. For this purpose, a total of 1304.5 quintals of seed cane of these improved varieties was used (Table 9.1).

at IISR, Lucknow, conducted at farmers' field in about 3.0 hectares.

Table 9.1. Details of varieties and quantity of seed cane used for demonstration

Variety	Year of release	Quantity of seed cane (q)	State for which recommended	Varietal characteristics			
				Maturity	Cane yield (t/ha)	Sucrose (%)	Resistant to
Co 0238	2009	297.9	Punjab, Haryana, Rajasthan, Uttarakhand, Central and Western Uttar Pradesh	Early	81.1	17.99	Red rot, wilt
CoPK 05191	2012	582.10	-do-	Early	81.1	17.06	Red rot
CoH 128	2012	304.48	-do-	Midlate	76.2	17.70	Red rot, wilt
Co 0118	2009	36.00	-do-	Early	78.2	18.45	Red rot smut, wilt
Co 05011	2012	84.00	-do-	Midlate	82.5	18.00	Red rot, wilt

Demonstration of new machine for planting sugarcane

The demonstration of Deep Furrow Sugarcane Planter, recently designed and developed

Live demonstration of IISR sugar machineries was conducted during Kisahn Goshthi-cum-exhibition at Rasoolpur Jattan, and Barwala villages of Muzaffarnagar district of UP on Dec. 13 & 14, 2014, respectively. The farmers were highly satisfied with the performance of this machine. Lectures were delivered by IISR scientists in the *Gosthi* as resource persons. Dr. Sanjeev Kumar Balyan, Hon'ble Minister of State for Agriculture and Food Processing Industries, Govt. of India was also present during the occasion.

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

To promote the adoption of Ratoon Promoter developed by IISR, demonstrations of this machine

was conducted in 13 villages covering 30 cane growers and 12 ha ratoon area in Biswan Sugar Mill (Sitapur) zone area. In all demonstration plots, ratoon promoter was operated/run in the months of January, February and March. The ratoon crop of cane varieties CoPK 05191, Co 0238, Co 0239, CoLk 94184, Co 05011, CoH 128, CoS 8436 and CoS 97264 was covered under demonstration. Pre-season and on-farm training sessions were organized to provide detail information in 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 beneficiary farmers' satisfaction with the operations like off-barring, deep tilling, interculturing/earthing up, fertilizer application and chemical application performed by ratoon promoter machine. At the same time, saving of average 30-35 labourers/ha and net saving in cost to the tune of Rs. 4,000-5,000/ha was recorded in demonstrated plots over check plot.

Entrepreneurship development for sugarcane seed and multiplication

To address the problem of availability of healthy seed material of new sugarcane varieties, a project on entrepreneurship in seed cane production is being implemented in command area of Biswan Sugar mill in Sitapur district of Uttar Pradesh. During the year 2014-2015, seed cane of five selected varieties, viz., CoLk 94184, CoPK 05191, Co 0118, Co 05011 and CoH 128 was planted on factory farm and farmers' fields in mill zone area. A total of 23 seed cane plots in 8.0 ha area was maintained in 11 villages. The crop was sown with recommended practices for seed cane crop raising. The average yield obtained for seed cane crop (CoLk 94184, CoPK 05191, Co 0238, Co 0118, Co 05011, CoH 128) raised during last season was 88 t/ha and harvested cane setts was utilized as seed material to raise seed cane crop in order to multiply the quantity of seed cane of new varieties. The regular monitoring of seed cane crop was done for observation on insect-pest infestation, disease incidence and any other disorder and suitable measures were adopted for effective management of crop.

The entrepreneurship training for beneficiary farmers was organised in the months of July, October and December to provide information in seed cane crop raising, motivate the farmers for enterprising in cane seed production and multiplication of new sugarcane varieties and to collect information for framing statements on traits of enterpreneur behaviour. Farmers were trained in techniques of seed cane production and they were educated about benefit of cane seed cultivation and multiplication in their own fields. To assess the entrepreneurial ability of farmers, 10 parameters/traits of Entrepreneur behaviour (EB), *viz*., risk taking, innovativeness, hope of success, persuasability, manageability, self-confidence, knowledgeability, persistence, use of feedback, achievement motivation were identified and four statements under each of EB traits were framed to collect response of farmers in three-point continuum against each of statement.

Table 9.2. Details of exhibitions organized by IISR, Lucknow

Event	Organizer	Place	Duration
Jaggery Carnival, National Meet on Jaggery & AICRP (Sugarcane) Annual Workshop	ICAR-IISR & ASTI, Lucknow	ICAR-IISR, Lucknow	Nov. 01-02, 2014
10th Indian Fisheries and Aquaculture Forum (10ifaf) and 5th Global Symposium in Aquaculture and Fisheries (GAF5)	Asian Fisheries Society, Indian Branch (AFSIB) Mangalore, India	ICAR-NBFGR, Lucknow	Nov. 12-15, 2014
Kisan Vigyan Samagam	ICAR-IISR, Lucknow	ICAR-IIFSR, Meerut	Jan. 23, 2015
Regional Agricultural Fair for eastern region	ICAR-CPRI & Indian Potato Association, Shimla	ICAR-CPRI Regional Station, Patna	Feb. 19-21, 2015
Agro-Tech 2015	International Agriculture Consulting Group and Agriculture Today Group	ICAR-IISR, Lucknow	March 12-14, 2015

On-station demonstration

To showcase the cane production technology to dignitaries and visitors, on-station demonstration in one ha area was laid out in Technology Park. Planting methods, Intercropping with sugarcane, IPM, Cane node technique and cane varieties were demonstrated.

Publicity of technology and events

Information on sugarcane technology was disseminated to large audience/different clientele groups through print (newspapers) and electronic media (TV and Radio). Wide publicity of events organized at the Institute was done through press releases published in newspapers and coverage of the events by electronic media. During the reported period, 125 news clippings/items was published in different newspapers published from Lucknow.

Kisan Vigyan Samagam at ICAR-IIFSR, Modipuram, Meerut

Kisan Vigyan Samagam was organized by IISR, Lucknow at IIFSR, Modipuram, Meerut on January 23, 2015. Exhibition of IISR sugarcane machineries was organised during the event. Dr. Sanjeev Kumar Balyan, Minister of State for Agriculture and Food Processing Industries, Govt. of India, during his inaugural address, highlighted that sugarcane is the backbone of agrarian economy. There is a need to enhance the sugar recovery by using quality seed of improved varieties.

Dr. Balyan appreciated the efforts of IISR and emphasized on strong coordination and linkage among the ICAR Research Institutes, SAUs and the sugarcane farmers to harness the untapped potential of sugarcane. *Samagam* was attended by more than 200 farmers and sugar factory representatives.

Dr. B. Gangwar, Director, Indian Institute of Farming System Research (IIFSR), Meerut highlighted that sugarcane farming is the most remunerative crop in western UP. Dr. H.S. Gaur, Vice-Chancellor, SVPUA&T, Meerut expressed his concern over the declining sugar recovery and stressed on the need for adoption of improved varieties in the region.

Dr. O.K. Sinha, Director, IISR, Lucknow explained the need of organizing *Kisan Vigyan Samagam* in western UP. He also expressed his concern that sugarcane farmers of this area need to be informed about the new improved varieties. He urged sugar mills to intensify development programme. He expressed satisfaction over considerable increase in area under new improved varieties.

Technology and Machinery Demonstration Mela at IISR, Lucknow

Indian Institute of Sugarcane Research, Lucknow organized 'Technology and Machinery Demonstration Mela' on March 20, 2015. The Mela was inaugurated by the Chief Guest, Dr. U.S. Gautam, Zonal Project Director, Zone IV, ICAR. In his address, Dr. Gautam stressed on the need of taking the developed implements and machinery to the farmers without any delay. Dr. Gautam emphasized on the development of machinery for small farmers to make the mechanization affordable to them. He called upon the farmers to take the benefits of various government schemes.

Highlighting the potential of machineries developed at IISR, Lucknow and their benefits, Dr. O.K. Sinha, Director, IISR pointed out that there is an urgent 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 AICRP on the Implement and Machinery and the Post-harvest Technology.

Dr. V.K. Shukla, Joint Cane Commissioner stressed on the need for mechanization in sugarcane keeping in view the labour scarcity and apprised the farmers that sugar mills have been asked to adopt maturity based cane harvesting which will not come in the way of easy adoption of farm harvesting machinery. Dr. R.P. Singh, Ex. Cane Advisor, Haryana Cooperative Sugar Mill Federation and Consultant, International Finance Corporation of the World Bank, representing Sugar Mills also shared his experience and stressed the need for proper utilization of sugarcane trash for improving the soil health and water retention capacity and emphasized the need for trash management machineries. The event was coordinated by Dr. A.K. Singh, Head, Division of Agricultural Engineering.

Apart from manufacturers, designers, scientists, extension officials of KVKs (Lucknow, Unnao, Sitapur and Lakhimpur Kheri) engineers, planners and policy makers, more than 800 farmers from Lucknow, Unnao, Sitapur, Shahjahanpur, Barabanki and Lakhimpur Kheri attended the *Mela*. During the *Mela*, farm machinery developed at IISR, Lucknow for mechanization of sugarcane agriculture and jaggery manufacturing technology was exhibited and explained to the farmers.

Live demonstrations of machineries were also performed. Main piece of attraction was field demonstration of sugarcane planter, trench planter with sub-surface drip laterals lying and sugarcane intercropping planter. The farmers were very curious and expressed satisfaction that their visit was very fruitful.

Sugarcane Mechanization Day at Harinagar, West Champaram, Bihar

Sugarcane Mechanization Day was organized at the Harinagar Sugar Mills, Harinagar, West Champaran, Bihar on September 26, 2014. The

Institute displayed many equipments developed for cane cultivation. Three manufacturers having MoA with IISR, *viz.*, M/s Motor & General Sales Ltd., Lucknow; M/s Shubham Agricultural Implements (P) Ltd. and M/s Punjab Engineers, Meerut.

Commercial power weeder, power tillers, self-propelled reaper binder and laser land levellers were also exhibited. Scientists and technical staff from IISR, Lucknow, officials from cane department, Govt. of Bihar, Harinagar and Hasanpur Sugar Mills and more than 2,000 farmers of Bihar attended the event.

IISR-Industry Interface on Enhancing Sugar Productivity in Uttarakhand

IISR-Industry Interface on "Enhancing sugar Productivity in Uttarakhand" was organized at Sugarbeet Breeding Outpost, IVRI campus, Mukteswar on July 03 and 04, 2014. The interface was chaired by Dr. S. Solomon, Director, IISR, Lucknow. In his presidential remarks, Dr. Solomon highlighted three points linked with sugarcane productivity in Uttarakhand as low productivity, low recovery and increasing cost of production. Uttarakhand is contributing sizeable amount of 33-35 lakh tonne of sugar as compared to national production of 25 mt.

Sugarcane yield and sugar recovery is 10% below the National average. Developmental issues are linked with low productivity. Presence of CoS 767 over 50% of area is an alarming situation. It needs to be replaced with breeder/quality seed production programme. Poplar intensification is affecting the productivity of sugarcane and wheat in the state. Emphasis is to be given for ratoon management bio-control programme. The chief guest, Sh. Y.P. Saini, Joint Cane and Sugar Commissioner, Govt. of Uttarakhand described the status of sugarcane and sugar mills in Uttarakhand. The large areas under sugarcane cultivation in two districts, Udham Singh Nagar and Haridwar was highlighted. He also highlighted the role of poplar in yield decline of sugarcane due to nutrient and water depletion. The lectures on production management, varietal aspects, integrated disease and pest management of sugarcane and sugarbeet were delivered.

Krishi Vigyan Kendra of IISR

On-farm testing/trials

During 2014-15, four on-farm trials 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 product in specific agro-climatic condition was undertaken for future recommendations and popularization as detailed below:

Evaluation of new high yielding varieties of wheat: Evaluation of high yielding varieties of wheat was carried out at six farmers' locations. All cultural practices and plant protection measures were followed. The highest yield was recorded in var. HD-2967 (47.25 q/ha) followed by DPW-621-50 (45.67 q/ha), and the lowest in farmers' variety PBW-343 (39.8 q/ha).

Performance of inter-cropping of turmeric and elephant foot yam in mango orchards: For improving productivity and profitability in mango orchard, there is a need to utilize spacing between fruit trees through inclusion of shade loving inter-crops *viz.*, turmeric and elephant foot yam. Keeping this in view, an experiment was laid out to find out the performance of intercropping of turmeric and elephant foot yam in two conditions, *i.e.*, i) dense canopy orchard, and ii) optimum canopy orchard. Results revealed that the highest yield of elephant foot yam (305 q/ha) was recorded with the optimum canopy orchard. However, under dense canopy conditions, plant growth was lean thin and lanky, hence, yield (108 q/ha) was not appreciable. The yield of turmeric was at par under both the conditions (245 and 225 q/ha, respectively).

Management of root rot and powdery mildew in vegetable pea: Vegetable pea is an important cash crop for vegetable growers of Lucknow district. For improving productivity, management of root rot and powdery mildew diseases are needed. Therefore, the performance of different fungicides in vegetable pea was evaluated. Results revealed that seed treatment with carboxin @ 3 g/kg seed and spray of Karathane (1.0 ml/l) reduced the incidence of root rot (1.5%) and powdery mildew (3.0%) which was significantly better over the farmers' practice (15.0 and 20.45%). Yield in seed treatment with carboxin @ 3 g/kg seed and spray of Karathane (1.0 ml/l) was increased 35.6% as compared to that of farmers' practice.

Effect on milk production through availability of green fodder: For providing green fodder availability round the year to milch animals, an on-farm trial was conducted to see the performance of different combination of cropping system. The results revealed that perennial grasses provided green fodder for 300 days and per cent increase in milk was 24% followed by farmers' practices - Berseem-Jowar-Chari (228 days) and minimum availability of green fodder (175 days) in Sorghum-Maize-cowpea cropping system.

Frontline demonstration: FLDs on oilseeds, pulses and other crops or enterprises were conducted at farmers' field. Two hundred forty three demonstrations at farmers' field in an area of 60.0 ha (27 ha under kharif and 33 ha under rabi. The increase in yield ranged from 2.6% in fieldpea to 56.0% in sesamum. The details of the frontline demonstrations are given in Table 9.3.

Training of farmers

Krishi Vigyan Kendra imparted 67 training courses for participating farmers, farm women, rural youth, sponsored and extension personnel on various topics with an objective to improve their skill and knowledge. All training programmes were fully skill oriented and conducted by following the principles of "Learning by doing". Total 1340 participants (1020 males and 320 females) attended the programme. In

Table 9.3. Details of FLDs conducted by KVK, IISR, Lucknow

Crop	Variety/Technology	Number of demonstrations	Area (ha)	Average yield (q/ha)	% increase over check
Sesamum	Shekhar	25	05	3.90	56.0
Mustard	Jagriti	13	03	7.25	7.4
	IPM for management of Aphid	05	02	6.85	6.2
Pigeonpea	Narendra Arhar 2	25	03	20.35	23.0
	IPM for management of pod borer	06	02	21.66	22.7
Fieldpea	KPMR 0522	48	05	19.0	2.6
Paddy	PAC 801	30	10	73.76	31.4
Wheat	PBW 550	18	05	39.70	08.5
	Zero tillage	08	05	38.5	05.2
Bottlegourd	Fruitfly trap	10	02	298.60	23.7
Tomato	IPM for management of fruit borer	14	01	670.30	18.2
Brinjal	IPM for management of shoot &fruit borer	14	01	585.5	14.0
Vegetable pea	Kashi Uday	25	02	75.6	25.6
Potato	Seed Plot Technique	05	05	319.3	16.8
Cauliflower	Girja	07	01	243.6	25.1
Sweet sorghum	SSH 22	16	05	435.5	29.8

Table 9.4. Details of extension activities undertaken by KVK, IISR, Lucknow during 2014-15

Activity	Programme	Farmers covered	Extension personnel participated	Total
Advisory services	120	2000	250	2250
Diagnostic visits	7	125	-	125
Group discussions	9	180	20	200
Kisan Goshthi	13	1250	25	1275
Film Show	25	500	16	516
Kisan Mela	2	1050	35	1085
Exhibition	3	750	30	780
Scientists' visit to farmers' field	97	320	15	335
Farmers' seminar/workshop	1	250	50	300
Method Demonstrations	14	42	-	42
Celebration of important days	02	300	20	320
Total	**293**	**6767**	**466**	**7228**

addition, following trainings were imparted with the sponsorship of various agencies:

- A two days training programme "Feed, fodder and diseases management of livestock organized on Feb. 6-7, 2015 for milk producers of Lucknow district under ATMA.
- One-day training programme "IPM in horticultural crops" was organized at KVK on Feb. 18, 2015 for extension personnel.

- One-day training programme was organized for Agri-clinic professionals at KVK on March 25, 2015.

Other extension activities: Following other extension activities were carried out:

Exhibition/Farmers' fair: Organized one farmers' fair and four technology exhibitions at Indian Institute of Sugarcane Research, Lucknow. About 9,600 farmers attended the programme.

Field visits: Nine groups of farmers (180) from different states under ATMA, Horticulture Mission scheme etc., visited KVK, Indian Institute of Sugarcane Research, Lucknow. During the visit, they were acquainted with innovative technologies.

PPV&FRA training programme for farmers: KVK organized a training programme on Plant Protection of Variety & Farmers' Right Act at Indian Institute of Farming System Research, Modipuram, Meerut on January 23, 2015 in which 350 farmers participated.

TV& Radio Talk: Six TV talk and six radio talk were delivered by KVK staff during the year 2014-15.

10

Farm section

The farm section is an important unit of the Institute having a net cultivable area of 132.22 ha, and facilitates research activities by providing logistic support including inputs, farm implements, labourers and other resources for field experimentation. In addition to commercial sugarcane production, the unit generates revenue by producing quality seed of sugarcane and other crops like wheat, paddy, mustard, gram, *etc.*

Major activities of the farm section

The activities which are being conducted by the farm section are enormous and having versatile nature. The main activities of the farm section:

1. To provide logistic support for conducting field experiments
2. Procurement and distribution of farm inputs
3. Maintenance of irrigation sources and system
4. Maintenance of farm machinery and implements
5. Seed production of sugarcane, wheat, paddy, *etc.*
6. Disposal of farm produce and revenue generation
7. Development and maintenance of the farm
8. Improvement of soil fertility
9. Labour management
10. Management of livestock

Seed production of sugarcane

During the period under report, 4736.23 q seed of sugarcane varieties CoLk 94184, CoPK 05191, Co 05011, etc., was produced and supplied to more than 100 stakeholders of which, 1135.29 q was provided to progressive farmers of western UP with an aim to ensure accelerated adoption of promising sugarcane varieties by the growers.

Revenue generation

The farm unit accrued ₹ 73,22,698/- (₹ Seventy three lakh twenty two thousand six hundred ninety eight only) as revenue from farm during the year despite drought adversely affecting the crops of sugarcane and paddy (Table 10.1).

Table 10.1. Revenue generated during the year 2014-15

Source/crop	Area (ha)	Yield (q/kg)	Amount received in 2014-15 (₹)	Outstanding amount in 2015-16 (₹)	Total Revenue (₹)
Sugarcane	**44.43**				
Seed	9.88	4736.23	12,92,401	4,05,660	16,98,061
Supply to sugar mill	43.55	7442.31	15,70,006	21,15,742	36,85,748
Sold for other purpose		160.02	43,267		43,267
Supplied to jaggary unit		564.83	0		0
Used as seed		2200	0		0
Sold in festival		8.12	8,120		8,120
Cane juice		6421	64,210		64,210
Sold as bulk & in bottle	lit.	4458	89,160		89,160
Jaggery	kg	4043	2,44,940		2,44,940
Vinegar	lit.	63.5	3,810		3,810
Sub-Total (A)			**33,15,914**	**25,21,402**	**58,37,316**
Wheat	**15.88**				0
Sale		11.11	16,665		16,665
General		491.3	6,87,820		6,87,820

Source/crop	Area (ha)	Yield (q/kg)	Amount received in 2014-15 (₹)	Outstanding amount in 2015-16 (₹)	Total Revenue (₹)
Used as seed		24.92	0		0
Used as cattle feed		23.6	0		0
Sub-Total (B)		**550.93**	**7,04,485**		**7,04,485**
Paddy	**18.2**				0
Sale		373.76	4,85,888		4,85,888
Auction		408.8	5,45,748		5,45,748
Kept as seed		2.1	0		0
Sub-Total (C)		**784.66**	**10,31,636**		**10,31,636**
Mustard & *Toria*	**15.92**				0
Sale		108.94	3,32,325		3,32,325
Used as seed		0.91	0		0
Sub-Total (D)		**109.85**	**3,32,325**		**3,32,325**
Gram	**8.17**				
Sale		111.29	3,43,449		3,43,449
Used as seed		8.64	0		0
Used as cattle feed		3.72	0		0
Sub-Total (E)		**123.65**	**3,43,449**		**3,43,449**
Pigeonpea	**12.85**				0
Sale		125.8	5,41,118		5,41,118
Used as seed		1.49	0		0
Cattle feed		13.8	0		0
Sub-Total (F)		**141.09**	**5,41,118**		**5,41,118**
Sesame	**5.8**	2.375	11,875		11,875
Bel/mango		Auction	50,000		50,000
Grass cutting			40,500		40,500
Sub-Total (G)			**1,02,375**		**1,02,375**
Grand total (A to G)			**63,71,302**	**2,,21,402**	**88,92,704**
Payment received from Haidergarh Sugar Mill, Barabanki during 2014-15					
Outstanding amount of 2013-14					15,70,006
Outstanding amt. of 2014-15 for supply of sugarcane seed and cane to sugar mill					
Outstanding payment for seed (ministers adopted village) - A					4,05,660
Outstanding payment (for supply to mill) up to March 2014-15 - B					21,15,742
Total outstanding amount of 2014-15 (A-B)					**25,21,402**
Total revenue for the year 2014-15 - C					88,92,704
Total amount received during the year 2014-15 - D					63,71,302
Outstanding amount of 2014-15 (C-D)					**25,21,402**
Total revenue for the year 2014-15 - E					88,92,704
Outstanding amount paid by Haidergarh Sugar Mill for the year 2013-14 - A					15,70,006
Net revenue or actual receipt during the year 2014-15 (E-A)					**73,22,698**
₹ Seventy three lakh twenty two thousand six hundred ninety eighty only					

11

Training and capacity building

Winter School on Novel Genomic Tools and Breeding approaches for Sugar Crops Improvement

A 21-days ICAR sponsored Winter School on "Novel Genomic Tools and Breeding approaches for Sugar Crops Improvement" was organised during Sept. 09-29, 2014 with Dr. Sangeeta Srivastava (Principal Scientist) as Course Director and Drs. Swapna M. and Sanjeev Kumar as Course Coordinators. Seventeen participants from various ICAR institutes, CSIR & and SAUs attended this winter school.

A series of lectures and hands-on practical sessions were conducted on various aspects of sugarcane breeding, genomics, transcriptomics, transgenics, production practices, protection strategies, physio-biochemical interventions, mechanization, etc. The participants also visited some of the local institutes to have a view of ongoing biotechnological research activities there.

Two compilations consisting of a compendium of lectures delivered during winter school, and a laboratory manual with protocols of different practical sessions were released on this occasion. The participants shared their views, discussed novel ideas, gave their feedback and left on a happy note, a little wiser about new emerging technologies for sugar crops improvement.

Training programme at IISR Biological Control Centre, Pravaranagar, Maharashtra

A three day training programme on "Technological interventions for enhancing cane and sugar productivity in Western Maharashtra" was organized during 14 to 16 Sept. 2014 at the IISR Biological Control Centre, Pravaranagar. In this training, more than 150 progressive cane growers of the area and 350 cane development staff of both the units of P.D.V.V.S.S.K. Ltd., Pravaranagar and Ganeshnagar participated. The training programme was inaugurated by the Chairman, Dr. Kharde Patil in the presence of factory trainees, speakers from MPKV, Rahuri, CSRS, Padegaon & scientists from IISR, Lucknow. While coordinating the training programme, Dr. S.N. Singh, Nodal Officer, IISR Biological Control Centre, Pravaranagar emphasized the need for establishment of Biological Control Centre, Pravaranagar for effective control of pest and diseases in sugarcane for enhancing yield of cane and sugar in Western Maharashtra. He further stressed the need for enhancing sugarcane productivity by way applying organic manures through cane trash, SPMC, green manuring, by adopting scientific crop rotation, organic manuring, intercropping in pre-seasonal sugarcane, etc. The Chairman of the mill Dr. Kharde Patil, Mr. S.C. More (Chief Agriculture Officer) stressed the need for adopting integrated management of inputs in sugarcane cultivation. Most of the trainees interacted with the speakers during the

course of deliberations. Farmers and cane development staff of both the sugar mills took keen interest in the training.

Training programme on quality jaggery making

Demonstration of improved technique for quality jaggery manufacturing was done at farm of Mr. Udayraj Parakh at Kavardha, Kabirdham (Chhattisgarh) on 14.12.2014.

Deputation abroad

- Dr R.K. Singh, Principal Scientist visited Plant Genome Mapping Laboratory, University of Georgia, Georgia as DBT CREST Fellow from Nov. 1, 2013 to Oct. 31, 2014. During the period he worked on "Association Mapping in Sugarcane" in collaboration with Dr. Andrew H. Paterson.
- Dr. S. Solomon, Director, IISR participated in the 3rd India Sugar Expo & International Conference –"Relevant Technologies for South East Asian Countries" held at Indonesia on May 21-22, 2014.
- Dr. S. Solomon Director, IISR and Dr A.D. Pathak, Principal Scientist & Head Division of Crop Improvement participated in the "Group Meeting of Experts on Sugar Crops Production" to promote sugarcane and tropical sugar beet cultivation in Thanh Hoa Province in North Vietnam during May 10-11, 2014 .

Table 11.1. Training programme organized

Name of training	Topic	Sponsoring agency	Duration	Level of participants (number)
Sponsored Students Training	Advances in Sugarcane Production Technology	Institute of Agricultural Sciences, BHU, Varanasi	June 20-27, 2014	B.Sc. (Ag.) Students of BHU (10)
National Training	Sugarcane Management and Development	Sugar mills	July 1-21, 2014	Cane development personnel of sugar mills (17)
Hands on Soil Analysis Training	Soil analyses protocols and methodology for determination of various nutrient elements	DSCL Group of Sugar Mills	July 22-28, 2014	Soil testing personnel (15)
Winter School	Novel Genomic Tools and Breeding approaches for Sugar Crops Improvement	ICAR, New Delhi	Sept. 09-29, 2014	Assistant Professor, Scientists (17)

Training programme	Technological interventions for enhancing cane and sugar productivity in Western Maharashtra at the IISR Biological Control Centre, Pravaranagar	Biological Control Centre, IISR, Pravaranagar	Sept. 14-16, 2014	Progressive cane growers (150), cane development staff (350)
Model Training Course	Integrated Nutrient Management for Improving Soil Health and Enhancing Nutrient Use Efficiency	Min. of Agric., Govt. of India	Oct. 13-20, 2014	Cane development personnel of sugar mills
Progressive farmers' training	Sugarcane Production Technology and Jaggery making	Touchstone Services Pvt. Ltd. Jabalpur	Oct. 15-17, 2014	Farmer entrepreneurs (03)
Farmers Training	Sugarcane Production Technology	Mahakaushal Sugar and Power industries Ltd. Bachai, Dist-Narsinghpur, M.P.	Nov. 05-07, 2014	Cane development personnel of sugar mill (07)
Demonstration	Improved technique for quality jaggery manufacturing at Kavardha, Distt. Kabirdham (Chhattisgarh)	IISR, Lucknow	Dec. 14, 2014	Farmer entrepreneurs
Farmers Training	*Ganna utpadan taknik*	ATMA, Motihari (Bihar)	Dec. 16-18, 2014	Farmers (20)
Farmers Training	*Ganna utpadan taknik*	Project Director, ATMA, Seoni, MP	Dec. 23-25, 2014	Farmers (14)
Students training	Sugarcane Production Technology	SHIATS, Allahabad	Jan. 19-25, 2015	B.Sc. (Ag.) students of SHIATS (20)
Training-cum-Awareness Programmes	Training-cum-Awareness Programmes on PPV&FRA	IIFSR, Modipuram, Meerut	Jan. 23, 2015	Farmers and sugar mill representatives
National Training	Planting methods for increasing plant population density and yield of sugarcane.	DAC, Ministry of Agriculture, Govt. of India	Feb. 16-17, 2015	Master trainers (16)
National Training	Integrated Nutrient Management in Sugarcane.	DAC, Ministry of Agriculture, Govt. of India	Feb. 23-24, 2015	Master trainers (15)
National Training	Inter cropping options in sugarcane for enhancing system productivity and profitability	DAC, Ministry of Agriculture, Govt. of India	Feb. 25-26, 2015	Master trainers (16)
National Training	Integrated pests and diseases management in sugarcane	DAC, Ministry of Agriculture, Govt. of India	Feb. 27-28, 2015	Master trainers (17)
National Training	Mechanisation of sugarcane cultivation and value addition	DAC, Ministry of Agriculture, Govt. of India	March 02-03, 2015	Master trainers (18)
Training programme	Feed fodder and diseases management of livestock	IISR-KVK, Lucknow	Feb. 6-7, 2015	Milk producers
Training for extension personnel	IPM in horticultural crops	IISR-KVK, Lucknow	Feb. 18, 2015	Extension personals

Table 11.2. Training received by IISR officials

Name of the official	Name of the training	Organised at	Date
Rajesh Kumar Singh, SK Holkar, Nithya K	Winter School on Novel Genomic Tools and Breeding Approaches for Sugar Crops Improvement	IISR, Lucknow	Sept. 09-29, 2014
Deepak Rai	Refresher course on IPM in Important Crops with special reference to Uttar Pradesh and Uttarakhand	ZPD, Kanpur	Sept. 26-27, 2014
AK Shrivastava	One day Training and Workshop on J-Gate @ CeRaA	NASC, New Delhi	September 29, 2014
G.K. Singh, Adil Zubair	Model Training course on Integrated Nutrient Management for Improving Soil Health and Enhancing Nutrient use efficiency	IISR, Lucknow	Oct. 13-20, 2014
SK Holkar	Training in Genomics of Plant Virus for Diagnosis and Utilization as Gene Expression Tool	IARI, New Delhi	Oct.15-Nov. 06, 2014
Rajesh Kumar Singh	Management development Programme on Emotional Intelligence for Personal and Work Excellence	NAARM, Hyderabad	Nov. 14-28, 2014
Veenika Singh	Recent trends in Value-addition of Subtropical Fruits for Nutritional Security and Secondary Agriculture	CISH, Lucknow	Nov. 5-25, 2014
G.K. Singh, Adil Zubair	National Training on Integrated Nutrient Management	IISR, Lucknow	Feb. 23-24, 2015

12

Awards and recognitions

Awards

Hon'ble President of India, Shri Pranab Mukherjee Ji conferred the coveted Indira Gandhi Rajbhasha Puraskar 2013-14 (Second Prize) in the "Kaa" region for the Government Magazines to Indian Institute of Sugarcane Research, Lucknow magazine "Ikshu" in a Function of Ministry of Home (Department of Official Languages), Govt. of India, New Delhi, New Delhi on Sept. 14, 2014.

Ikshu- Rajbhasha Patrika Varsh 3: Ank 2 (January-July, 2014) was awarded First Prize by erstwhile Nagar Rajbhasha Karyanvayan Samiti, Lucknow.

AK Sah received Best Poster Award for the poster entitled "Out grower model of cane development in India" during 5th IAPSIT International Sugar Conference (IS-2014): Green Technologies for Sustainable Growth of Sugar and Integrated Industries in Developing Countries", (Nov. 25-28), Nanning, P.R. China.

AK Sharma and Brahm Prakash received Best Poster Award for the poster entitled "Role of sugarcane cultivation in agricultural development of Uttar Pradesh" in 2nd UP Agricultural Science Congress at IISR, Lucknow.

AK Singh and S Solomon received Best Poster Presentation Award for the poster entitled "Mechanization of sugarcane cultivation in developing countries: IISR efforts" during 5th IAPSIT International Sugar Conference (IS-2014): Green Technologies for Sustainable Growth of Sugar and Integrated Industries in Developing Countries", (Nov. 25-28), Nanning, P.R. China.

AK Singh and S Solomon was awarded Dr. Rajendra Prasad Puruskar-2013 for Technical Books in Hindi in Agricultural and Allied Sciences by the ICAR, New Delhi for the book entitled "Ganna Aadharit Fasal Paddhatiyan: Badalta Paridrashya Evam Takniki Vikas".

AK Singh received Rajiv Gandhi Gyan Vigyan National Award-2012 for writing book in Hindi entitled "Ganna Adharit Fasal Padhtaiyan: Badalta Paridrishya avam Takniki Vikas" the award was presented by Hon'ble President of India on Sept. 14, 2014 at Rashtrapati Bhavan, New Delhi.

Chandra Gupta was awarded Best Oral Presentation Award for presentation entitled "Drip irrigation under different planting methods of sugarcane: A comparative study in tropical region of Tamilnadu in National Seminar on Recent Advances and Challenges in sugarcane Research, at Mysore organised by ZARS, Mandya.

Deeksha Joshi, KS Hooda and JC Bhatt received Best Poster Presentation Award for poster entitled "Biological control of soil-borne pathogens and growth promotion by potent Trichoderma isolates under North Western Himalayan conditions" in the International Symposium on Innovations in Horticulture for Improving Nutritional Security, Conserving Biodiversity and Poverty Alleviation" (Oct. 16-18, 2014), BBAU, Lucknow.

RK Rai, S. Solomon and Pushpa Singh received Best Sugarcane Agriculture Paper Award for Sugar as well as Allied Industry by "Bharatiya Sugar" in the 2nd Annual Sugar Convention (Oct. 13-14, 2014), Rajaram College, Kolhapur.

RK Singh, Programme Coordinator, IISR-KVK, Lucknow received KVK Professional Award-2014 by Society of Extension Education, Agra in 7th National Conference of Extension Education, (Nov. 8-11, 2014), ICAR Research Complex, Meghalya.

RK Singh, Programme Coordinator, IISR-KVK, Lucknow received Excellent KVK Scientist Award-2014 by Indian Society of Extension Education, IARI, New Delhi.

S Solomon was conferred Life Time Achievement award by IAPSIT (International Association of Professionals in Sugar and Integrated Technology) for his unparalleled scientific contribution in post-harvest technology of sugarcane and sugar processing, during 5th IAPSIT International Sugar Conference (IS-2014): Green Technologies for Sustainable Growth of Sugar and Integrated Industries in Developing Countries", (Nov. 25-28), Nanning, P.R. China.

Sangeeta Srivastava received the SAB 2014 Award of Excellence in Plant Genomics by The Society for Applied Biotechnology at Asian Plant Science Conference, Lumbini, Nepal on Nov. 2, 2014.

Sangeeta Srivastava was awarded Professor Uma Kant Sinha Memorial Lecture Award 2014 by the Indian Botanical Society.

Sangeeta Srivastava was nominated as Fellow of Society for Applied Biotechnology in 2014.

SK Shukla received FAI Golden Jubilee Award-2014 (gold medal, citation) and cash prize of Rs 50000 (Rs fifty thousand only shared among three) for Excellence in the field of nutrient management in sugarcane. Fertiliser Association of India, New Delhi.

SK Shukla received ISA Fellow-2014, a certificate, medal and citation by Indian Society of Agronomy (ISA), New Delhi on Dec. 10, 2014.

SK Shukla received Noel Deerr Gold Medal for paper presentation entitled "How to improve carbon sequestration in sugarcane based system for sustaining soil health and improving sugarcane productivity in subtropical India?" Sep 9-11, 2014, at NIMHANS Convention Centre, Bengaluru, organized by STAI, New Delhi.

SK Shukla, S Solomon, SK Awasthi and Asha Gaur received Second Prize in Poster Presentation entitled Etheral treated seed cane vis-à-vis microbial consortia and crop residue management in sugarcane planted after wheat harvest in subtropical India in National Symposium on Agricultural Diversification for Sustainable Livelihood and Environment Security, (Nov 18-20, 2014), PAU Ludhiana.

TK Srivastava was conferred with Fellowship of Indian Society of Agronomy.

Recognitions

Amresh Chandra acted as Co-chairman of a session in Symposium on Bio-energy for sustainable development- The potential role of sugar crops at SBI, Coimbatore during June 23-25, 2014

Amresh Chandra acted as Convener of ICAR Regional Committee No. IV meeting held at IISR, Lucknow during Sept. 1-2, 2014

Amresh Chandra served as a member of Project Evaluation Committee, UPCAR Lucknow.

Amresh Chandra served as Associate Editor of the journal Acta Phygiologiae Plantarum.

Amresh Chandra was Co-ordinator of a session during 5th IAPSIT International Sugar Conference (IS-2014): Green Technologies for Sustainable Growth of Sugar and Integrated Industries in Developing Countries", (Nov. 25-28), Nanning, P.R. China.

Amresh Chandra was Organizing Secretary of NAAS Meeting (Lucknow Chapter) to dwell upon to reduce the cost of cane cultivation, (Dec. 29, 2014), IISR Lucknow.

Dilip Kumar and PrasoonVerma acted as Co-Organizing Secretary for the National Meet on Modernization of Jaggery Industry in India and Jaggery Carnival held at IISR, Lucknow on Nov. 01-02, 2014.

Ram K Singh nominated as Member of Board of Studies of Biotechnology Program at Devi Ahilya University, Indore.

Ram K Singh served as member of Editorial Board of the journal Sugar Tech and Physiology Molecular Biology of Plants.

Ram K Singh was awarded Annual Membership of American Phytopathological Society (APS), USA for the year 2014-15.

Sangeeta Srivastava served as a member of the editorial board of three journals: Sugar Tech, J. Environ. Biol., and Indian J. Fundamental Appl. Life Sci.

Sangeeta Srivastava served as Course Director of 21 Days ICAR sponsored Winter School on 'Novel Genomic Tools and Breeding Approaches for Sugar Crop Improvement' held at IISR, Lucknow from Sept. 09 to 29, 2014.

Sangeeta Srivastava served as the Chairperson, Agri-Biotechnology Session, National conference on Bioengineering and Biotechnology: An Industrial Perspective held at Amity University, Lucknow during Oct. 16-17, 2014.

Sangeeta Srivastava was nominated by the ICAR and Ministry of Consumer Affairs, Food & Public Distribution, Directorate of Sugar as Reviewer for mid-term review of Sugar Development Fund project at GBPUA&T, Pantnagar in 2014.

SI Anwar acted as Member, Project Monitoring Committee, Ministry of Environment and Forest, New Delhi.

SI Anwar acted as Organizing Secretary, National Meet on Modernization of Jaggery Industry in India, (Nov. 01-02, 2014), IISR, Lucknow.

SN Singh was nominated as Member, Regional Agro Advisory Group, NABARD, Lucknow.

SN Singh was nominated as Member-Secretary, Research Advisory Committee of IISR by the ICAR, New Delhi.

SS Hasan, S Solomon, A Baitha, MR Singh, AK Sah, SK Shukla and R Kumar received Best Poster Presentation Award for poster entitled "Development of diagnostic expert system in sugarcane using object oriented knowledge representation technique" in 5thIAPSIT International Sugar Conference (IS-2014) Green Technologies for Sustainable Growth of Sugar & Integrated Industries in Developing Countries (Nov. 25-28, 2014), Nanning, China.

Swapna M and Sanjeev Kumar served as Course Coordinator of 21 Days ICAR sponsored Winter School on 'Novel Genomic Tools and Breeding Approaches for Sugar Crop Improvement' held at IISR, Lucknow from Sept. 09 to 29, 2014.

TK Srivastava acted as Coordinator of Technical Session II: Sugar Crops Production Technologies and Mechanization in the 5th IAPSIT International Sugar Conference (IS-2014): Green Technologies for Sustainable Growth of Sugar and Integrated Industries in Developing Countries", (Nov. 25-28), Nanning, P.R. China.

TK Srivastava served as Editor, Indian Journal of Agronomy for the biennium 2013-14.

TK Srivastava was nominated as Member-Secretary, QRT of IISR, AICRP (S) and KVK by the ICAR, New Delhi.

13

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.

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 cane sugar production.
3. Development of low-cost technologies for sugarcane production.
4. Intensifying and extending the networking facility and information generation for transfer of technology to the farmers and sugar industry.

30th Biennial Workshop of AICRP on Sugarcane

The 30th Biennial Workshop of All India Coordinated Research Project on Sugarcane was organized at Indian Institute of Sugarcane Research, Lucknow on November 1 & 2, 2014. The Opening Session was held under the chairmanship of Dr. N. Gopalakrishnan, ADG (CC), ICAR, New Delhi. He remarked that despite increasing population of the country coupled with associated challenges in sugarcane cultivation and marketing, a target sugar production of about 36 mt, with sugarcane production of about 600 mt, cane productivity of about 100 t/ha and sugar recovery of 11% is to be achieved by 2030.

Dr. Bakshi Ram, Director, Sugarcane Breeding Institute, Coimbatore in his introductory remarks highlighted the importance of sugarcane varieties. He laid emphasis on the need to change the varietal adoption scenario by developing smart cane varieties based on emerging demand for high tonnage, sugar and fibre. Dr. O.K. Sinha, Project Coordinator (Sugarcane) presented the Annual Progress Report of AICRP on Sugarcane for the year 2013-14 under Crop Improvement, Crop Production, Plant Pathology and Entomology disciplines.

Dr. N. Gopalakrishnan, ADG (CC), ICAR, expressed his satisfaction on the research work being undertaken by IISR, Lucknow, SBI, Coimbatore and AICRP on Sugarcane. He desired that biotechnological tools may be utilized for managing diseases and insect-pests in a more effective manner. He remarked that now there is a need to develop climate resilient varieties and suitable cultivation package in view of change in climate.

Salient Research Achievements

Crop Improvement

Zonal varietal trial : In Peninsular Zone, the entry VSI 08121 in early maturity group were found promising. It was found more stable than the widely adapted variety CoC 671. In midlate group, Co 08009 and Co 08008 were found more stable than the widely adapted variety Co 86032. In East Coast Zone, CoC 10337 in midlate group was the superior entry. In North Central & North East Zones, CoSe 08451 in midlate maturity group was most promising entry. It was more stable than the widely adapted variety CoSe 92423. In North West Zone, CoPb 08212 and CoS 08233, in early group, were the superior entries and stable with respect to cane yield and sucrose (%). CoPb 08217 and CoH 08264 in midlate group performed better. The entry CoPb 08217 was more stable than the widely adapted variety CoS 767.

Fluff supply programme: During the year, Breeders of AICRP centres performed crossing work at the National Hybridization Garden and National Distant Hybridization Facility at SBI, Coimbatore. Under Fluff Supply Programme, 43.88 kg fluff was produced from station crosses, zonal crosses, polycrosses and general collections. Fluff was supplied to AICRP centres for seedling raising and selection.

Varieties Identified: Till date, a total of 113 varieties have been identified in AICRP on Sugarcane and of these 48 varieties have been released and notified for cultivation in different parts of the country. In 2013, five varieties viz., CoLk 07201 and Co 06034 (for North West Zone); CoP 06436 (for North Central Zone); and CoA 08323 and CoC 08336 (for East Coast Zone) were identified. This year, two varieties of peninsular zone, CoSnk 05103 and CoSnk 05104 have been notified.

New Research Programme: In view of climate change and adoption of mechanized harvesting sugarcane in tropical region, two new programmes *viz*., Evaluation and identification of cliamate resilient ISH genetic stocks and wider row spacing for evaluation of varieties under zonal varietal trial have been initiated under Crop Improvement discipline.

Besides, The stability of varieties under Advanced Varietal Trial 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.

Crop Production

Agronomic evaluation of promising genotypes showed that 100% of recommended doses of fertilizers were sufficient for achieving higher cane and sugar yield. However, at Pantnagar in North West Zone, Pusa in North Central Zone, Padegaon and Kolhapur in Peninsular Zone, and Anakapalle and Cuddalore centres in East Coast Zone, 125% of recommended doses of nitrogen promoted significantly higher cane yield of new varieties.

To facilitate mechanized harvesting in sugarcane, planting geometry under paired row (30:120 cm) in North West and North Central Zones and paired row 30:150 cm in Peninsular Zone was most suitable with respect to response on cane yield; however, at Navsari and Padegaon 120 cm row spacing was most suitable.

Response of NPK, micro- and secondary nutrients as well as FYM on sugarcane showed that application of recommended doses of NPK alongwith sulphur, zinc, iron and manganese promoted significantly higher cane yield at 9 centres followed by soil test based fertilizer application at 6 centres irrespective of the zone.

To enhace cane 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, Lucknow and Pantnagar. However, in Uchani, Kapurthala, Powarkheda and Pusa, significantly higheer cane yield was recorded with intercropping of autumn sugarcane and wheat sown in two rows between sugarcane. Padegaon centre located in Peninsular zone also conducted the study and reported that sugarcane and wheat intercropping remunerative when 3 rows of wheat were sown in between sugarcane.

To improve germination in sugarcane, priming of cane node with cattle dung + cattle urine + water in 1:2:5 ratio was found to be the most effective at 8 centres. As compared to conventional planting with 3-bud setts, planting of primed cane nodes helps in substantially reducing the quantity of seed cane.

At Faridkot, surface drip and at Lucknow centre, sub-surface drip at 125% pan evaporation produced a significantly higher cane yield and NMC. However, at Lucknow centre, irrigation water-use efficiency was significantly higher under sub-surface drip irrigation at 75% pan evaporation.

Plant Pathology

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

A total of 84 entries were evaluated for red rot, smut and wilt resisance. Red rot reaction ranged from moderately resistant to highly susceptible by plug and nodal cotton swab method for evaluation of varieties for red rot resistance. At 5 centres, 67 ISH clones were evaluated for red rot resistance.

Survey reports indicated prevalence of red rot in all the sugarcane growing states except Maharashtra, Karnataka and Madhya Pradesh. High incidence of red rot was recorded in Haryana, A.P. and Tamilnadu. Mostly old varieties were affected with red rot. Smut incidence was in general, lower except in Andhra Pradesh and Tamil Nadu. Wilt incidence was higher in Bihar, Madhya Pradesh and Andhra Pradesh. Grassy shoot disease was severe in western U.P. and Andhra Pradesh. Higher incidence of rust (up to 60%) was recorded in Maharashtra and Andhra Pradesh. Sugarcane yellow leaf disease incidence was higher in Andhra Pradesh and Tamil Nadu. Pokkah boeng incidence was low except in Haryana and Uttarakhand. Brown spot disease is gaining importance in Maharashtra.

For management of rust disease, propineb (0.25%) and mancozeb (0.3%) were the most effective fungicides. Assessment of field resistance of varieties to red rot by sorghum grain inoculum method has not indicated field resistance in any of the susceptible varieties except at Coimbatore centre where 13 susceptible varieties showed field resistance.

For evaluating varieties against brown rust, methodology for inoculating pathogen is being developed. At Padegaon, Sankeshwar and Anakapalle centres, the experiment was conducted and at all the three centres leaf whorl method of inoculation was found to be the most effective.

Varieties were screened against pokkah boeng disease and some resistant ones were identified at Uchani, Shahjahanpur, Pune, Kolhapur and Anakapalle centres. Epidemiological studies indicated that the disease is favoured by high humidity, high rainfall and lower temperature. The disease appears at the onset of monsoon. At 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 thirteen zonal entries were evaluated against major insect pests of the region. Grades of insect-pest infestation in varieties were reported. Simple and cost-effective mass multiplication technologies have been developed for bioagents like *Beauvaria bassaiana* and *Micromus igorotus.*

Survey for major insect pests indicated high incidence of early shoot borer in Haryana and Andhra Pradesh and black bug, root borer, stalk borer and pyrilla in Haryana. Top borer incidence was relatively lower this year. Mealy bug, scale insect and internode borer incidence was very high in Maharashtra. Pyrilla was severe in M.P. and central U.P. and red mite in A.P.

Monitoring of insect pests and bioagents was carried out in sugarcane agro-ecosystem. As recorded in previous years, bioagents of top borer, stalk borer, pyrilla, whitefly, woolly aphid, scale insect, mealy bug and early shoot borer were prevalent.

Testing bioefficacy of insecticides against mealy bugs at Navsari centre showed that treatment of setts with imidacloprid 70 WG/SP @ 25 g a/i./ha followed by spray application of imidacloprid 17.8 SL @ 0.005% after 4-5 months of planting effectively reduced intensity of mealy bug.

Population dynamics of sugarcane borers, *viz*., early shoot borer, top borer, internode borer and stalk borer was studied through pheromone traps. The number of captures was dependendent on meteorological parameters, particularly temperature, relative humidity and rainfall. The lures effectively reduced incidence of borers.

For management of early shoot borer with new insecticide, soil application of chlorantraniliprole 0.4 G @ 22.5 kg/ha at the time of planting and 60 days after planting or chlorantraniliprole 18.5 SC @ 375 ml/ha applied as spray after 30 and 60 days of planting was found to be the most effective.

Technologies developed and recommended

- **Identification of sugarcane variety**

  During AICRP Workshop-2014, sugarcane variety PI 07131 (early maturing) was identified for release in peninsular zone.

- **Plant geometry in relation to mechanization in sugarcane**

  Wider row spacing of 120 cm/30:150 cm is recommended for tropical zone to facilitate the mechanical harvesting as well as maintain cane yield level. However, in sub-tropical zone, sugarcane planting at 30:120 cm is an option to facilitate mechanization.

- **Chemical control of brown rust of sugarcane**

  Application of two sprays of propineb @ 0.2% or mancozeb @ 0.30% at 15 days intervals soon after the appearance of rust symptoms is recommended for the effective management of rust disease.

- **Management of sugarcane mealy bug**

  Sett treatment with imidacloprid 70 WG/ SP @ 25g a.i./ha or thiamethoxam 70 WG/ SP @ 25g a.i./ha followed by spraying of imidacloprid 17.8 SL 0.005% cent at the time of cane formation was effective for the management of sugarcane mealy bug.

Zonal Breeders & Pathologists Meet

All India Co-ordinated Research Project on Sugarcane organized the Zonal Breeders and Pathologists Meet for North West, North Central & North East Zones on 6th & 7th February, 2015 at the Regional Research Station (PAU), Gurdaspur. The main agenda for the meeting were: (i) Selecting the superior test entries from Initial Varietal Trial (IVT) for evaluating them in Advanced Varietal Trial (AVT), (ii) Finalizing the zonal and polycrosses, and (iii) Finalization of entries under climate resilient genetic stocks.

Inaugural function was held on 6th February, 2015. Dr. R. S. Singh, Director, Regional Research Station, Gurdaspur welcomed the participants who came from AICRP centres in subtropical zone. In the Introductory remarks, Dr. O.K.Sinha, Project Coordinator, AICRP on Sugarcane informed the house that Gurdaspur borer, a major localized pest in sugarcane, was originally reported in this area. At present more than seven sugar mills are operating in and around Gurdaspur. He informed that in this meeting the test entries in IVT will be promoted to AVT based on quality parameters, reaction to red rot and field stand.

Dr. P. Govindraj, Principal Scientist, SBI, Coimbatore & Principal Investigator (Crop Improvement), AICRP(S), elaborated the contributions of AICRP(S) in sustaining the sugarcane production and meeting the emerging needs of the farmers and millers. Critical analysis of the genetic improvement of the clones developed in North West Zone from 1993-94 to 2006-07 has indicated 32% and 27.14% improvement for early and midlate varieties, respectively over these periods. However, juice quality had not increased significantly. Varieties adapted to wider row spacing, micro-irrigation, self-detrashing, plant types suitable to mechanical harvesting, and resistance to emerging biotic and abiotic stresses are being developed to meet the future needs.

Dr. R.K. Gumber, Additional Director of Research, PAU, Ludhiana highlighted research achievements. He expressed concern on declining area under sugarcane and shortage of labourers during harvesting.

Dr. Bakshi Ram, Director, Sugarcane Breeding Institute, Coimbatore remarked that the general belief of negative relationship between high cane yield and high sucrose of early maturing varieties has been disproved with the development and release of Co 0238 and Co 0118 varieties. These varieties recorded more than 15% improvement in cane yield as well as juice quality. It is now possible to achieve 100 t/ha of cane yield in subtropical region with the improved varieties in combination with appropriate crop production and protection technologies.

Dr. Balwinder Singh, Director Research, PAU, in his Inaugural address, stated that CoJ 64, the wonder variety, has increased number of sugar mills and the area under sugarcane. To overcome the problem of area reduction, such type of varieties need to be developed.

The Technical Session was chaired by Dr. Bakshi Ram, Director, SBI, Coimbatore. After in-depth discussion, IVT entries were shortlisted and promoted to AVT. A new set of zonal crosses were identified for North West Zone. The parental composition of polycross nursery for sub tropical zone was modified. The Chairman suggested the Breeders and Pathologists on the following points:

i) Many centres are mostly utilizing their own clones as parent in crossing programme as which leads to inbreeding. Wide cross combination should be identified to create more variability and effective selection.

ii) Grading of the test entries should be made in comparison with the best standard of the trial while evaluating them for promoting from IVT to AVT. The performance of crop may be recorded as poor/on par/better in comparison to the best standard and should be reported during Zonal Breeders & Pathologists Meet.

iii) Care may be taken by the pathologists in screening of varieties against red rot to avoid large variation in rating.

iv) Passport data are not available for some of the clones planted in NHG. The passport data compiled so far will be uploaded in the ICAR-SBI website for the benefit of the breeders. It is essential that any new clone added to the NHG should be accompanied with passport data.

v) Physiological manipulation of flowering is carried out for inducing/delaying/advancing flowering at NHG for utilizing in crossing programme. Breeders may utilize such facility to make crosses.

14

Publications

Research papers

International journals

Banerjee N, Siraree A, Yadav S, Kumar S, Singh J, Kumar S, Pandey DK, Singh RK. 2015. Marker-trait association study for sucrose and yield contributing traits in sugarcane *(Saccharum* spp. hybrid). *Euphytica* (online first; doi: 10.1007/s10681-015-1422-3).

Banerji R, Solomon S, Kumar R, Kishor R, Singh P and Chandra A. 2014. Inhibitory effect of pre-harvest foliar application of zinc sulphate on sucrose inversion in the harvested sugarcane. *Sugar Tech* 17(3): 322–324.

Chandra A, Grisham MP and Pan YB. 2014. Allelic divergence and cultivar-specific SSR alleles revealed by capillary electrophoresis using fluorescence-labeled SSR markers in sugarcane. *Genome* 57: 363-372.

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. *Mol. Biol. Rep.* (online first; doi: 10.1007/s11033-015-3875-9).

Chandra A, Roopendra K, Sharma A, Jain R and Solomon S. 2014. Partial sequence of soluble acid invertase gene from *S. spontaneum*- A first report. *Natl. Acad. Sci. Lett.* 37: 317-323.

Chandra A, Roopendra K, Singh P, Jain R, Prajapati CP and Solomon S. 2014. Time-course expression of soluble acid invertase (SAI) gene mirroring post-harvest cane quality deterioration: Effective treatments cause reduction of SAI gene expression. *Curr. Sci.* 107: 184-186.

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 Biol.* (online first; doi: 10.1111/plb.12276).

Gupta R and Khan MZ. 2014. Effect of distillery effluent (spent wash) application on aggregate size distribution and stability in sodic soils. *Sugar Tech* (online first; doi 10.1007/s12355-014-0326-1).

Hasan SS, Baitha A, Singh MR, Sah AK, Kumar R and Shukla SK. 2014. Expert system approach to diagnose disorders in sugarcane *(Saccharum officinarum). Curr. Adv. Agril. Sci.* 6(2): 148-153.

Hasan SS, Solomon S, Baitha A, Singh MR, Sah AK, Kumar R and Shukla SK. 2014. Cane Des: A web based expert system for disorder diagnosis in sugarcane. *Sugar Tech* (online first; doi 10.1007/s12355-014-0341-2).

Jain R, Chandra A, Vishakumari V and Solomon S. 2015. Physiological change and expression of *SOD* and *P5CS* genes in response to water deficit in sugarcane. *Sugar Tech* 17(3): 276–282.

Jain R, Verma R, Singh A, Chandra A and Solomon S. 2015. Influence of selenium on metallo-thionein gene expression and physiological characteristics of sugarcane plants. *Plant Growth Reg.* (online first; doi 10.1007/s10725-015-0042-1).

Jain RK, Bikash M, Pappu HR and Holkar SK. 2015. A new species proposal for inclusion of Watermelon bud necrosis virus (WBNV) in the genus *Tospovirus* as a distinct virus species isolated from *Citrullus lanatus* and other cucurbitaceous hosts. Modules attached. Approved by *International Committee on Taxonomy of Viruses* (ICTV), (www.ictv.talkonline.com).

Keizerweerd AT, Chandra A and Grisham MP. 2015. Development of an RT-LAMP assay for the detection of sugarcane mosaic and sorghum mosaic viruses in sugarcane. *J. Virological Methods* 37: 317-323.

Khan MS, Basel K, Ganeshan P, Gupta RS, Singh J, Duttamajumder SK and Kapur R. 2014. Subtractive hybridization-mediated analysis of genes and *in silico* prediction of associated microRNAs under water-logged conditions in sugarcane (*Saccharum* spp.). *FEBS Open Bio* 4: 533-541.

Kumar S, Tiwari AK, Holkar SK, Duttamajumder SK and Rao GP. 2015. Characterization of a 16 SrI-B subgroup phytoplasma associated with sugarcane leaf yellows disease in India. *Sugar Tech* 17: 156-161.

Mishra AK, Shukla SK, Yadav DV and Awasthi SK. 2014. Iron, manganese and sulphur uptake and nutrients availability in sugarcane based system in subtropical India. *Sugar Tech* 16(3): 300-310.

Pathak AD, Kapur R, Solomon S, Kumar R, Srivastava S and Singh PR. 2014. Sugarbeet: A historical perspective in Indian context. *Sugar Tech* 16(2): 125-132.

Rai RK, Singh P and Solomon S. 2013. Effect of sodium chloride and sodium sulphate on growth, water relations and solute adjustment in two sugarcane varieties. *Indian J. Sugarcane Technol.* 28 (02): 61-72.

Shrivastava AK, Solomon S, Rai RK, Singh P, Chandra A, Jain R and Shukla SP. 2014. Physiological interventions for enhancing sugarcane and sugar productivity. *Sugar Tech* (doi 10.1007/s12355-014-0321-6).

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 AK and Solomon S. 2015. Development of a sugarcane detrasher. *Sugar Tech* 17(2): 189-194.

Singh P, Rai RK, Suman A, Srivastava TK, Singh KP, Arya N and Yadav RL. 2014. Soil-root interface changes in sugarcane plant and ratoon crops under subtropical conditions: Implications for dry-matter accumulation. *Comm. Soil Sci. Plant Analysis* 46(4): 454-475.

Singh PK, Kumar S and Singh J. 2014. A need of farmer centric marking system for plant varieties in seed market of India. *Curr. Sci.* 107(8): 1231-1232.

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 Sci.* (online first).

Verma RR, Singh KP and Srivastava TK. 2014. Nutrient status in sugarcane growing soils of Haryana. *Curr. Adv. Agril. Sci.* 6(1): 20-23.

National Journals

Bajpai PK, Singh J, Hasan SS and Kumar R. 2014. Minimum number of seedlings for evaluation of crosses in sugarcane. *Indian J. Sugarcane Technol.* 29(1): 13-16.

Prakash B, Sharma AK and Ashfaque M. 2014. Immense scope for women in sugarcane based cottage industries. *Indian J. Agril. Marketing* 28(3): 100.

Sharma AK and Prakash B. 2014. Extent of Women Participation in Sugarcane Production and Marketing in India. *Indian J. Agril. Marketing* 28(3): 99.

Sharma AK and Prakash B. 2014. Informal livestock trade and opportunities for small dairy units in Central Uttar Pradesh. *Indian J. Agril. Econ.* 69(3): 314-315.

Sharma AK and Prakash B. 2014. Problems and prospects of mechanization in labour intensive sugarcane crop in India. *Indian J. Agril. Econ.* 69(3): 368-369.

Singh AK, Yadav RL, Pathak AD and Suman A. 2014. Agronomic feat of early maturing sugarcane genotypes grown with and without organics in sub-tropical India. *Indian J. Agron.* (Accepted).

Singh AK, Yadav RL, Pathak AD and Suman A. 2014. Effect of integrated nutrition on nitrogen use efficiency, productivity and quality of mid-late maturing sugarcane genotypes under sub-tropical Indian conditions. *Indian J. Sugarcane Technol.* 28(2): 91-94.

Singh SN, Sah AK, Singh RK, Singh VK, Singh RK and Prakash O. 2012. Production potential and economic feasibility of improved sugarcane based cropping system. *Indian J. Extension Edu.* 48(3-4): 101-103.

Srivastava TK, Singh KP and Singh P. 2014. Organic sugarcane production systems for enhanced soil health and crop productivity. *Indian J. Sugarcane Technol.* 29(2): 41-50.

Vasantha S, Gupta C, Shekinah ED. 2014. Physiological studies on tiller production and its senescence in sugarcane: Response comparison between plant and ratoon crops. *Indian J. Agril. Sci.* 84(1): 24-27.

Verma RR, Srivastava TK and Singh KP. 2014. Soil macro and micro nutrient status in sugarcane growing soils of Haridwar district, Uttarakhand (India). *Indian J. Sugarcane Technol.* 29(2): 72-76.

Gangwar LS, Hasan SS and Solomon S. 2014. Economic benefits of CaneDES: An ICT based software for sugarcane disease and disorders diagnosis in India- An *ex ante* evaluation. *Agril. Econ. Res. Rev.* 27: 192.

Books/Proceedings/Compendium/Policy Papers

Gangwar LS, Solomon S, Singh P, Hasan SS and Sah AK. 2014. Socio-economic impact of sugarcane production and diversification in India. IISR, Lucknow.

Gangwar LS, Solomon S and Anwar SI. 2015. Technological and policy options for modernization of jaggery industry in India (ICAR-IISR/Policy brief), p. 6.

Sah AK, Singh SN and Solomon S. 2014.Ganna Kisan Margdarshika (Farmers' Guide to Sugarcane Cultivation), IISR, Lucknow, p. 190.

Shukla SK, Baitha A and Solomon S. 2014. Compendium on integrated nutrient management for improving soil health and nutrient use efficiency. IISR, Lucknow, p.182.

Solomon S, Jain R, Chandra A, Shukla SK, Lal RJ, Venugopalan VK, Nithya K, Holker SK, Singh MR, Prakash B and Ashfaque M. 2014. Sugarcane: A voyage from sett to sweeteners. IISR, Lucknow, p. 111.

Solomon S, Sharma AK and Shukla SK. 2014. Technorama-IISR: Sixty technologies developed by IISR. IISR, Lucknow, p. 68.

Training manual/proceedings/annual report compilation

Singh J, Srivastava S, Kumar S, Singh P, Singh PK, Srivastava TK, Sharma AK, Joshi D, Srivastava AK, Prakash B, Singh N and Singh AK. 2014. Annual Report 2013-14, IISR, Lucknow, p. 90.

Srivastava S and Kumar S. 2014. Laboratory manual: ICAR sponsored winter school on novel genomic tools and breeding approaches for sugar crops improvement, IISR, Lucknow, p. 108.

Srivastava S, Anwar SI, Verma P, Kumar D, Swapna M, Prakash B and Ashfaque M. 2014. Jaggery: Evolution to revolution. Souvenir-cum-Proceedings of national meet on modernization of jaggery industry in India, IISR, Lucknow, p. 195.

Srivastava S, Swapna M and Kumar S. 2014. Compendium of Lectures: ICAR sponsored winter school on novel genomic tools and breeding approaches for sugar crops improvement, IISR, Lucknow, p. 260.

Verma RR, Singh SR and Srivastva TK. 2014. Training manual on soil analysis for sugar mill personnel. IISR, Lucknow.

Popular articles

Anwar SI, Singh RD and Pandey PR. 2014. Aonlayukta gur-vitamin C ka strot. *Krishak Shrinkhala*. May, 33-34.

Anwar SI. 2014. Mithas- Wah Ya Aah. *Ikshu* 3(1): 104.

Awasthi SK and Shukla SK. 2013. *Trichoderma* evam *Gluconacetobacter* ka mrida swasthya par prabhaav. *Ikshu* 2(1): 19-21.

Awasthi SK, Gaur A, Nigam M, Shukla SK and Swaha S. 2014. Mrida ke suksm jeevon ko prabhavit karne wale karak. *Kisan Jyoti* 4(4): 100-103.

Dubey S, Sah U, Singh AK, Singh AK, Chaturvedi SK and Singh RK. 2015. Chana beej utpadan me prachhetra manak. *Kisan Jyoti* 17-19.

Dubey S, Sah U, Singh AK, Singh AK, Chaturvedi SK and Singh RK. 2015. Chana beej utpadan men parikshan avm gurwatta manak. *Kisan Jyoti* 30-33.

Gaur A, Awasthi SK, Singh R, Nigam M, Shukla SK and Shee S. 2014. Rituon ke pariwartan ka mrida soochhm jeevon ki kriyasheelta tathaa phasal ki utpadakta par prabhaaw. *Ikshu* 3(2): 23-24.

Gaur A, Singh R, Nigam M and Shukla SK. 2014. Jaivik urvarakon ke prayog se mrida swathya evam phasal utpadakta mein vraddhi. *Ikshu* 3(1): 35-36.

Hasan SS and Sah AK. 2014. Ganne mein koi bhi samastya: CaneDes hai na. *Chaupal* 1(3): 34-35.

Hasan SS, Bajpai PK, Gangwar LS and Verma MR. 2014. Ganne mein vikar pahchaan ki visheshagya pranali. *Ikshu* 3(1): 22-24.

Hasan SS. 2014. Ganne ki kheti mein gyan prabandhan. *Ikshu* 3(1): 13-15.

Jain R, Singh N, Lal P, Chandra A, Shrivastava AK and Solomon S. 2014. Ganna beej gunan hetu

bud chip prodhagiki. *Kheti* Dec.: 14-16.

Joshi D and Singh RK. 2014. Women farmers of India and their agricultural innovations. *WFO Farmletter* 26, April 2014.

Kumar A and Rai D. 2015. Gehu ki unnat kheti. *Kisan Jyoti* 1-5.

Lal RJ, Joshi D, Singh D and Awasthi SK. 2014. *Trichoderma* key upyog dwara mirda urbarakta mai bridhi tatha ganney key rogo ka niyantran. *Ikshu* 3(2): 57-59.

Prakash B and Sharma AK. 2014. Basantkallen ganne ke sath mung evam urd ki atahafasli kheti. *Ikshu* 2(2): 27-28.

Prakash B and Sharma AK. 2014. Milawati khadhya padarthon ke sevan se manav swastha ka bachav aavashyak. *Ikshu* 3(2): 63-65.

Prakash B, Sharma AK and Ashfaque M. 2014. Computer par khoob kaam karein parantu savdhani ke saath. *Ikshu* 3(2): 80-82.

Rai RK, Singh P and Solomon S. 2014. Ganne men carban tatwa ka bibhinna utkon men vibhajan. *Kheti* 37-39.

Sah AK. 2014. Ganna utpadan ke liye sanstut unnat krishi taknik. *Ikshu* 3(2): 17-20.

Sah AK. 2015. Vaigyanik vidhi se karen basantkaleen ganne kee buwai. *Chaupal* 1(10): 11-14.

Sah AK. 2014. Unnat ganna utpadan ke liye krishi taknik. *Chaupal* 1(2): 34-37.

Sah AK. 2014. Uttar Bharat mein ganna utpadan ke liye unnat krishi taknik. *Ikshu* 3(1): 4-7.

Sah AK. 2014. Vaigyanik samajh se badhayen bees pheesdi upaj. *Chaupal* 1(4): 6-9.

Sah AK. 2014. Vaigyanikon aur kishanon ke beech talmel jaruri. *Chaupal* 1(6): 10-12.

Sah AK. 2015. Bahut meethee hai ganne ke milwan kheti. *Chaupal* 1(8): 14-15.

Sah AK. 2015. Milwan kheti me poshak tatva prabandhan jaruri. *Chaupal* 1(9): 20-21.

Sharma, A.K. and Prakash B. 2014. Bharat mein cheeni neetiyan evam ganna krishi ka tikaupan. *Ikshu* 3(1): 33-34.

Shukla SK, Awasthi SK, Gaur A, Singh GK and Singh V. 2014. Uttar bharat mein pedi ganne se adhik upaj prapt karne ke liye unnat krishi taknik. *Ikshu* 3(1): 16-19.

Singh A, Shrivastava AK and Gangwar LS. 2014. Adhunik bharat mein pustakalayon ka vikas. *Ikshu* 3(2): 77.

Singh BD, Sah AK, Pathak AD. 2015. Eikh beej utpadan kee takneekee. *Krishak Shrinkhla* March, 12(3): 11-12.

Singh MR, Hasan SS and Sharma MP. 2014. Gharelu rogvahak keet va unka niyantran. *Kisan Jyoti* 4: 113-118.

Singh MR, Hasan SS and Sharma MP. 2014.Madhu makkhi ya maun palan. *Ikshu* 3(1): 57-61.

Singh MR. 2014. Deemak, chuhe aur lataon se bachaayein ganna. *Chaupal* 1(8):12-13.

Singh MR. 2014. Ganne ki mithaash choosne walon ko lagaayein thikaane. *Chaupal* 1(6): 34-35.

Singh MR. 2014. Keeton se bachaayein ganne ki khadi fasal. *Chaupal* 1(4): 16.

Singh P, Joshi D and Rai RK. 2014. Ganna krishi evam udyog mein mahilaaon ki saajhedaari. *Kheti* 66(11): 100-103.

Singh RK and Singh AK. 2015. Laghu avm simant krishkon ke liye bakari palan. *Kisan Jyoti* 87-93.

Singh RK, Prakash B, Singh RK and Rai D. 2014. Basantkaleen ganne ki labhdayak kheti. *Khad Patrika* 55(3): 31-38.

Singh SN, Sah AK, Singh PR, Singh I, Singh RK and Dullu. 2015. Improvement in cane productivity through relay intercropping of autumn sugarcane with skipped row transplanted rice. *Indian Farming* 65(1): 09-11.

Singh V, Thakur S, Rai D and Singh RK. 2015. Aarogyakari kharbooj. *Kisan Jyoti* 87-93.

Srivastava TK, Singh KP and Singh P. 2014. Bio-manured multi-ratooning enhances sugarcane plant-ratoon system productivity. *Indian Farming* 64 (8): 12-16.

Verma RR, Singh AK and Srivastava TK. 2014. Kaise surakshit karain khet me achcha ganna jamav pratishat ? *Ikshu* 3(2): 14-16.

Verma SP and Singh RK. 2015. Nanotechnology tatha pashudhan utpadan men anuprayog. *Kisan Jyoti* 82-83.

Book Chapters

Chattopadhyay A, Holkar SK and Meena SC. 2014. Recent molecular genetics and biotechnological approaches in mushroom research. In. Microbial Biodiversity in Sustainable Agriculture (Ed. Ram Chandra), Daya Publishing House, New Delhi, pp. 323-343.

Kapur R. and Swapna M. 2014. Sugarcane. In. Breeding Field Crops I: Practices (ed. VL

Chopra), Studium Press LLC, p. 650.

Paper presented at seminars/symposia/ conference

Anwar SI and Singh PR. 2015. Concept of efficiency boosting device for improving thermal efficiency of open pan jaggery furnaces. In. Proc. 49th Annual Convention and Symposium of ISAE, (Feb. 23-25), PAU, Ludhiana, p. 90.

Arya N, Tripathi N, Rai RK, Anwar SI and Singh P. 2014. Non-conformities in subtropical and tropical jaggery attributes: Impact on shelf-life of jaggery: In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 186.

Ashfaque M, Prakash B and Sharma AK. 2014. IP status of jaggery: Trends, constraints and prospects. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 123.

Ashfaque M, Prakash B and Sharma AK. 2014. IPR system in ICAR: Experiences and lessons. In. Proc. 2nd UP Agricultural Science Congress, (June 14-16), IISR, Lucknow, p. 409.

Bajpai PK, Bhradwaj A, Gangwar LS and Verma MR. 2014. Impact of Gur and khandsari industry on sugar consumption level. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 135.

Chandra A, Roopendra K, Sharma A, Singh P, Prajapati CP, Jain R and Solomon S. 2014. Exploring post-harvest sucrose loss in sugarcane due to exogenous and endogenous invertases *vis-a-vis* molecular aspects of its management. In. Proc. "Intl. Conf. IS-2014: Green technologies for sustainable growth of sugar and integrated industries in developing countries", (Nov. 25-28), Nanning, P.R. China, p.

Chandra A, Yong BP, Grisham MP and Solomon S. 2015. Sugarcane genomics: CE-based allelic divergence and molecular detection of sugarcane major diseases. In. Proc. 12th Agricultural Science Congress (Feb. 3-6), NDRI, Karnal, p. 41.

Dohare RS, Kumar R and Sinha OK. 2014. Jaggery-based ethno-veterinary practices in live stock production and management. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 130.

Gangwar LS, Hasan SS, Verma MR and Bajpai PK. 2014. Jaggery and Khandsari production and consumption in India- An economic analysis. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 97.

Gangwar LS. 2014. Sugarcane production and supply chain management for product diversification- An economic perspectives. In. Souv. CIPHET Silver Jubilee Sem. "Present status and future strategies for processing and value-addition of agricultural commodities", CIPHET, Ludhiana, p. 126-134.

Gupta C, Kumar R, Dohare RS, Gangwar LS and Singh M. 2014. A study of jaggery production in eastern Uttar Pradesh. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 136.

Gupta C, Sinha OK, Singh G K and Singh RK. 2014. Vibhinna paudh poshak tatvon ka ganne ki phasal par prabhav. In. "15th Rashtriya Krishi Vigyan Sangosthi", (Dec. 5-7), RVSKV, Gwalior, p. 37-38.

Gupta R and Singh PR. 2014. Design and development of sub-surface drip laterals laying attachment with deep trench paired row sugarcane planter. In. Proc. "73rd Annual Convention of the STAI", (Sept. 9-11), Benguluru, p. 46-51.

Gupta R. 2015. Comparative performance of drip and surface irrigation for sugarcane cultivation. In. Souv. "49th Annual Convention of the ISAE", (Feb. 23-25), PAU Ludhiana, p. 201.

Hasan SS, Anwar SI, Gangwar LS, Sah AK, Bajpai PK and Kumar R. 2014. A multimedia Based expert system model for establishment and operation of jaggery units. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 193.

Hasan SS, Solomon S, Baitha A, Singh MR, Sah AK, Shukla SK and Kumar R. 2014. Development of diagnostic expert system in sugarcane using object oriented knowledge representation technique. In. Proc. "Intl. Conf. IS-2014: Green technologies for sustainable growth of sugar and integrated industries in developing countries", (Nov. 25-28), Nanning, P.R. China, p. 71.

Hasan SS. 2014. An integrated optimization approach for developing web-based expert system with usability concern. In. Souv. Intl. Conf. "Modeling and Computing (ICMC-2014),

(July 10-11), BBAU, Lucknow, p. 35.

Hasan SS. 2014. Classified diagnostic knowledge approach to address usability issues of disorder diagnosis expert system in agriculture. In. Proc. "Computer Application and Signal Processing", doi: 10.3850/978-981-09-2579-6_P008.

Hasan SS. 2014. Ontology-based generic model for the development of an expert system to diagnose disorders caused by biological pests in agriculture. In. Proc. Intl. Symp. "Advances in Biological and Material Science", (July 15), University of Lucknow, Lucknow, p. 64.

Holkar SK, Mandal B and Jain RK. 2014. Reaction of the watermelon genotypes for Watermelon bud necrosis virus under field and glass house conditions. In. Proc. Natl. Conf. "Recent Trends in Virology Research in the Omics Era (VIROCON)", (Dec. 18-20), TNAU, Coimbatore, p. 169.

Joshi D, Hooda KS and Bhatt JC. 2014. Biological control of soil-borne pathogens and growth promotion by potent *Trichoderma* isolates under North Western Himalayan conditions. In. Proc. Intl. Symp. "Innovations in Horticulture for Improving Nutritional Security, Conserving Biodiversity and Poverty Alleviation", (Oct. 16-18), BBAU, Lucknow, p. 223.

Joshi D, Singh P, Singh AK and Lal RJ. 2015. Secondary metabolites of biocontrol agent *Trichoderma*: A potential tool for effective and sustainable management of red rot of sugarcane. In. Proc. Intl. Workshop "Bridging Development Divide for Inclusive Growth through Science, Technology and Innovation", (Jan. 16-17), BBAU, Lucknow, p. 62.

Joshi D, Singh P, Singh AK, Lal RJ and Lal P. 2015. Studies on isolation and biochemical variability of *Trichoderma* isolated from different sugarcane ecosystems. In. Proc. Natl. Symp. "Recent Advances in Diagnostic and Management of Diseases of Field and Horticultural Crops", (Feb. 28-March 01), NDAU&T, Faizabad, p. 37-38.

Kishor R, Chandra A and Anwar SI. 2014. Use of gur as health friendly sweetener: Problem and prospective. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 131.

Kumar D and Singh J. 2015. Determination of gas permeability of different polymeric films used in modified atmospheric packaging. In. Proc. 49th Annual Convention and Symposium of ISAE, (Feb. 23-25), PAU, Ludhiana, p. 50.

Kumar R, Sinha OK, Dohare RS, Rai RK and Singh P. 2014. A sampling strategy for estimating district/state level jaggery, bagasse and khandsari production rates from sugarcane in India. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 132-133.

Kumar S, Banerjee N, Siraree A and Singh RK. 2014. Antioxidant and cytoprotective properties of jaggery. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India and Jaggery Carnival", (Nov. 1-2), IISR, Lucknow, p. 130-131.

Kumar S, Singh J and Singh PK. 2014. Traits-based selection approach to improve the ratooning ability in sugarcane varieties of sub-tropical India. In: Proc. Natl. Symp. "Crop Improvement for Inclusive Sustainable Development", (Nov. 7-9), PAU, Ludhiana, pp. 120-121.

Kumar S, Singh J, Singh PK and Pandey DK. 2014. Sugarcane varietal improvement for jaggery production: A farmer's perspective. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India", (Nov. 1-2), IISR, Lucknow, p. 144.

Kumar S, Singh PK and Singh J. 2014. Evaluation of Ikshu ISH clones for total biomass yield and sugar content and their utilization in bioenergy production. In: Proc. Symp. "Bioenergy for Sustainable Development: The Potential Role of Sugar Crops", (June 23-25) SBI, Coimbatore, pp. 85-86.

Lal RJ, Joshi D and Singh AK. 2014. *Trichoderma* sp.: Current status and implication for its use in sugarcane disease management and enhancing cane productivity. In. Proc. "Intl. Conf. IS-2014: Green technologies for sustainable growth of sugar and integrated industries in developing countries", (Nov. 25-28), Nanning, P.R. China, p. 128.

Lal RJ. 2015. Sugarcane diseases and their integrated management. In. Proc. Natl. Symp. "Recent Advances in Diagnostic and Management of Diseases of Field and Horticultural Crops", (Feb. 28-March 01), NDAU&T, Faizabad, p. 10-12.

Lal S and Singh D. 2014. Microbes affecting jaggery

storage and associated biological hazards. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p.189 -190.

Lal S, Panwar L and Singh RK. 2014. In vitro effect of *Trichoderma* species on *Colletotrichum falcatum* causing red rot of sugarcane. In. Proc. Natl. Conf. "Bioengineering and Biotechnology: An Industrial Perspective", (Oct. 16-17), Amity University, Lucknow, p. 13.

Lal S, Panwar L and Singh RK. 2015. Biological activity of fungal endophytes against *Colletotrichum falcatum* causing red rot of sugarcane. In. Proc. Natl. Symp. "Recent Advances in Diagnostic and Management of Diseases of Field and Horticultural Crops", (Feb. 28-March 01), NDAU&T, Faizabad, p. 97-98.

Lal S, Singh RK, Saba I and Panwar L. 2015. Assessment of genetic diversity and relationship among stalk and midrib isolates of *Colletotrichum falcatum* causing sugarcane red rot. In. Proc. Natl. Symp. "Recent Advances in Diagnostic and Management of Diseases of Field and Horticultural Crops", (Feb. 28-March 01), NDAU&T, Faizabad, p. 21.

Lal S, Singh RK, Saba I, Panwar L and Lal RJ. 2014. Genetic diversity of *Trichoderma* spp.: An antagonist against *Colletotrichum falcatum*. In. Proc. Intl. Symp. "Biodiversity: Status, Utilization and Impact of Challenging Climatic Conditions," (Oct. 30-31), BBAU, Lucknow, p. 240.

Mishra S, Arya N, Tripathi N, Rai RK, Anwar SI and Singh P. 2014. Physical and chemical composition of 12 years old jaggery. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 187.

Nithya K, Lal RJ and Joshi D. 2014. Rural women entrepreneurship and modernization of jaggery industry in India. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 176.

Pandey DK, Singh PK, Lal S, Singh J and Kumar S. 2014. Effect of red rot incidence on juice and gur quality in sugarcane varieties. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 147.

Pathak AD, Kapur R, Srivastava S, Anwar SI, Joshi BB and Saxena VK. 2014. Sugarbeet: A potential source of jaggery. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 106.

Pathak AD, Kumar R, Singh BD and Joshi BB. 2014. Screening of sugarcane genotypes for jaggery quality. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 143.

Pathak AD, Singh MR, Srivastava S, Rai RK, Kumar R and Solomon S. 2014. Induction of top shoot borer tolerance in sugarcane through introgression of genes from *Saccharum* complex. In. Proc. "Intl. Conf. IS-2014: Green Technologies for Sustainable Growth of Sugar and Integrated Industries in Developing Countries", (Nov. 25-28), Nanning, P.R. China, p. 103.

Pathak AD, Solomon S, Kapur R and Chandra A. 2014. Exploring potential of sugarbeet for sugar and ethanol. In. Proc. Symp. "Bioenergy for sustainable development-Potential Role of Sugar Crops" (June 23-25) Sugarcane Breeding Institute, Coimbatore, p. 298.

Pathak AK, Kapur R, Srivastava S, Anwar SI, Joshi BB, and Saxena VK. 2014. Sugarbeet: A potential source of jiggery. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 106.

Prakash B, Sharma AK, Ashfaque M and Pant DC. 2014. Export potential of jaggery in India. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 133.

Prakash O, Singh SR, Singh SN, Singh S and Shahabuddin M. 2014. Integrated plant nutrient management plays a key role in sustainable sugarcane production and development in soil fertility status. In Proc. Conf. "Bio-energy for sustainable development: The Potential Role of Sugar Crops", (June 23-25), SBI, Coimbatore, p. 35.

Rai D and Singh RK. 2014. Performance of IPM module in tomato crop with farmer participatory. In. 7th National Extension Education Congress (Nov. 08-11), ICAR Research Complex, Meghalaya.

Roopendra K, Chandra A, Saxena S and Solomon S. 2015. Perturbation of source-sink communication: A stepping stone for increasing source productivity in sugarcane. In. Proc. 5th Intl. Conf. "Next Generation

Genomics and Integrated Breeding for Crop Improvement", (Feb. 18-20), ICRISAT, Hyderabad, p. 142.

Sah AK and Hasan SS. 2014. ICT intervention in knowledge convergence for inclusive growth of sugar industry. In. Proc. "73rd Annual Convention of STAI", (Sept. 9-11), Bangaluru, p. 126-134.

Sah AK and Solomon S. 2014. Out grower model of cane development transforming farmers' and sugar mill economy: An Indian experience. In. Proc. "Intl. Conf. IS-2014: Green technologies for sustainable growth of sugar and integrated industries in developing countries", (Nov. 25-28), Nanning, P.R. China, p. 161.

Sah AK, Singh SN and Singh MR. 2014. Ways and means to modernize jaggery industry: an urgent imperative. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 165-166.

Sharma AK and Prakash B. 2014. Issues in declining sugarcane productivity in Uttar Pradesh. In. Proc. All India Sem. "Diminishing Sugarcane Productivity & Sugar Recovery in Northern India: Opportunities and Challenges", (July 18), STAI, Lucknow.

Sharma AK and Prakash B. 2014. Role of sugarcane cultivation in agricultural development of Uttar Pradesh. In. Proc. 2nd UP Agricultural Science Congress", (June 14-16), IISR, Lucknow, p. 414-415.

Sharma AK, Prakash B and Ashfaque M. 2015. Problems and prospects of mechanization in labour intensive sugarcane crop in India. In. Proc. "XII Agricultural Science Congress", (Feb. 3-6), NDRI, Karnal, p. 255-256.

Sharma AK, Prakash B, Ashfaque M and Solomon S. 2014. Challenges and prospects of organic sugarcane cultivation in weak sugar state of Himachal Pradesh. In. Proc. Natl. Sem. "Organic Agriculture- Challenges & Prospects", (May 28-29), CSKHPKV, Palampur, p. 187-188.

Sharma AK, Solomon S and Prakash B. 2014. Issues in jaggery production and marketing in India. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 45-49.

Shrivastava AK, Singh J, Singh P, Rai RK, Shukla SP and Solomon S. 2014. Morpho-physiologic manifestation of compensatory ability in sugarcane. In. Proc. Natl. Sem. "ICM in sugarcane for increasing cane, sugar and jaggery yields", (Dec. 5-6), Andhra University, Vishakhapatnam, p. 63-70.

Shrivastava AK, Singh P, Rai RK, Singh J, Srivastava S and Solomon S. 2014. Modernizing jaggery industry in India: Constraints and development strategies. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 50-55.

Shrivastava AK, Singh P, Shukla SP, Rai RK and Solomon S. 2014. Jaggery (gur) standards: Codex Alimentarius vs. Indian Standards. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 166-168.

Shukla SK and Solomon S. 2014. Do organic sources help in sustaining sugarcane yield? In. Proc. "73rd Annual Convention of STAI", (Sept. 9-11), Bengaluru, p. 58-69.

Shukla SK, Solomon S, Awasthi SK and Gaur A. 2014. Etheral treated seed cane vis-a-vis microbial consortia and crop residue management in sugarcane planted after wheat harvest. In. Proc. Natl. Symp. "Agricultural Diversification for Sustainable Livelihood and Environment Security", (Nov. 18-20), PAU, Ludhiana, p. 900-901.

Shukla SK, Solomon S, Srivastava TK, Gaur A, Awasthi SK, Swaha S, Kumar S and Singh K. 2014. Carbon sequestration vis-à-vis improved crop productivity through crop residue recycling in sugarcane and rice-wheat cropping system. In. Proc. "Intl. Conf. IS-2014: Green technologies for sustainable growth of sugar and integrated industries in developing countries", (Nov. 25-28), Nanning, P.R. China, p. 61.

Shukla SK, Swaha S, Awasthi SK and Gaur A. 2014. Jaggery and khandsari: Constraints analysis and opportunities in India. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 98.

Shukla SP, Prajapati CP, Sawanani A, Chaurasia RS, Chandra A and Shrivastava AK. 2014. Jaggery/gur in managing malnutrition in children and women. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 137.

Singh AK and Solomon S. 2014. Mechanization of

sugarcane cultivation in developing countries: IISR efforts. In. Proc. "Intl. Conf. IS-2014: Green technologies for sustainable growth of sugar and integrated industries in developing countries", (Nov. 25-28), Nanning, P.R. China, p. 554-555.

Singh AK and Solomon S. 2015. Development of cane node planter. In. Proc. "49th Annual Convention of ISAE", (Feb. 23-25), PAU, Ludhiana, p. 114.

Singh AK, Joshi D and Lal RJ. 2014. Jaggery/molasses: A suitable raw material for mass multiplication of *Trichoderma*. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 160-161.

Singh AK, Joshi D and Lal RJ. 2015. Evaluation of different substrates for mass multiplication of *Trichoderma harzianum* and its shelf life studies. In. Proc. Natl. Symp. "Recent Advances in Diagnostic and Management of Diseases of Field and Horticultural Crops", (Feb. 28-March 01), NDAU&T, Faizabad, p. 101.

Singh AK, Sharma MP, Solomon S and Singh PR. 2014. Development of machineries for paired row sugarcane cultivation. In. Proc. All India Seminar "Appropriate Technologies of Farm Mechanization for Marginal and Small Farmers", (Aug. 8-9), IEI, Kolkata, p. 16.

Singh AK, Srivastava TK and Singh I. 2014. Planting method cum material diversification for high shoot population density and cane productivity under Indian sub-tropics. In. Proc. Natl. Symp. "Agricultural Diversification for Sustainable Livelihood and Environmental Security, (Nov. 18-20), PAU, Ludhiana.

Singh AK, Srivastava TK, Singh AK, Singh SN, Yadav DV, Sharma MP and Singh PN. 2014. Green techniques of water application in sugarcane for sub-tropical India. In. Proc. "Intl. Conf. IS-2014: Green technologies for sustainable growth of sugar and integrated industries in developing countries", (Nov. 25-28), Nanning, P.R. China, p. 72.

Singh AK. 2014. Recent advancement in organic sugarcane cultivation for manufacture of organic jaggery. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 155-156.

Singh BD, Sahabuddin M and Pathak AD. 2014. Jaggery production: A novel approach. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 100.

Singh D and Tripathi A. 2015. Novel tools for detection and seed treatments of seed abnormalities with special reference to seed-borne diseases. In. Proc. Natl. Symp. "Recent Advances in Diagnostic and Management of Diseases of Field and Horticultural Crops", (Feb. 28-March 01), NDAU&T, Faizabad, p.24.

Singh D, Lal RJ, Pandey N and Rajendarprasad S. 2014. Diversity of seed-borne mycoflora in relation to different wheat varieties in wheat-sugarcane based cropping system. In. Proc. Intl. Symp. "Diversity: Status, Utilization and Impact of Challenging Climatic Conditions", (Oct. 30-31), BBAU, Lucknow, p. 45.

Singh D, Lal S, Joshi D and Lal RJ. 2014. Red rot: A serious threat for production of quality jaggery. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 147.

Singh D, Tripathi A, Lal S and Lal RJ. 2015. Distribution of seed-borne pathogens in commonly cultivated chickpea varieties of Uttar Pradesh. In. Proc. Natl. Symp. "Recent Advances in Diagnostic and Management of Diseases of Field and Horticultural Crops", (Feb. 28-March 01), NDAU&T, Faizabad, p.53.

Singh GK and Zubair A. 2014. Role of planting geometry and N and nutrition in yield and quality of sugarcane ratoon. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow.

Singh GK, Zubair A and Dohare RS. 2014. Ganne mein ekikrit poshak tatva prabandhan. In. "15th Rashtriya Krishi Vigyan Sangosthi", (Dec. 5-7), RVSKV, Gwalior, p. 36.

Singh GK, Zubair A and Prakash B. 2014. Climate resilient forage production and its utilization. In. Proc. Natl. Symp. "Climate Resilient Forage Production and its Utilization, (Nov. 13-14), BCKVV, Kalyani.

Singh I and Singh SN. 2015. Enhancing sugarcane productivity and profitability under wheat-sugarcane cropping through furrow irrigated raised bed (FIRB) system. In. Proc. "Second International Conference on Bioresource and

Stress Management", (Jan. 7-10), PJTSAU, Hyderabad, p. 174.

Singh J, Singh PK, Kumar S and Pandey DK. 2014. Selection of sugarcane varieties suitable for late planting conditions. In: Proc. Natl. Symp. "Crop Improvement for Inclusive Sustainable Development (Nov. 7-9), PAU, Ludhiana, p. 126.

Singh N, Prakash B, Sharma AK and Ashfaque M. 2014. Medicinal properties of jaggery. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 127-128.

Singh PK, Kumar S, Pandey DK and Singh J. 2014. Farmers' participatory approach for 'on farm assessment' of sugarcane varieties released from different sources over the years. In: Proc. Natl. Symp. "Crop Improvement for Inclusive Sustainable Development (Nov. 7-9), PAU, Ludhiana, pp. 76-77.

Singh PK, Singh M and Siraree A. 2014. The prebiotics edge for jaggery over white sugar. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 128.

Singh PR and Gupta R. 2014. Design and development of sugarcane-cum-potato planter for intercropping of potato with sugarcane. Proc. "73rd Annual Convention of STAI", (Sept. 9-11), Bengaluru, p. 52-57.

Singh PR, Gupta R and Singh AK. 2015. Design and development of modified automatic sugarcane-cum-potato planter. In. Proc. "49th Annual Convention of the ISAE", (Feb. 23-25), PAU, Ludhiana, p.118.

Singh PR, Singh AK, Singh S and Gupta R. 2014. Development of plant residue shredder for sugarcane trash management. In. Proc. Symp. "Bioenergy for Sustainable Development-The potential role of sugar crops", (June 23-25), SBI, Coimbatore, p. 165-166.

Singh R, Rai RK, Singh P, Shrivastava AK, Solomon S and Arya N. 2014. Organic jaggery: A healthy alternative. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 120.

Singh RD, Singh J and Kumar D. 2015. Performance evaluation of natural convention solar dryer for jaggery drying. In. Proc. "49th Annual Convention of the ISAE", (Feb. 23-25), PAU, Ludhiana.

Singh RK, Banerjee N, Lal R, Kumar S, Patel JD, Guo H, Zhang Dand Paterson AH. 2014. Putative candidate genes associated with resistance to different races of *Colletotrichum falcatum* in sugarcane. In. Proc. "Intl. Conf. IS-2014: Green technologies for sustainable growth of sugar and integrated industries in developing countries", (Nov. 25-28), Nanning, P.R. China, p. 305-306.

Singh RK, Khan MS, Banerjee N, Yadav S, Kumar S, Dattamajumder SK, Zhong D, Patel JD and Paterson AH. 2014. Linkage disequilibrium-based association mapping of red rot resistance in sugarcane. In. Joint Meeting of APS-CPS, Session: Molecular/Cellular/Plant-Microbe Interactions, (Aug. 9-13), Minneapolis, Minnesota, USA, p. 282.

Singh RK, Sharma AK, Singh RK and Rai D. 2015. Prospects of sweet sorghum silage feeding to dairy cows water scarce area in UP. In. Proc. "Animal Nutrition Conference on Eco-responsive Feeding and Nutrition", AAU, Jorhat, p. 132.

Singh RK, Singh RK and Prakash B. 2014. Potentiality of sweet sorghum [Sorghum bicolour (L.)] for jaggery production. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 105-106.

Singh RK. 2014. Effect of irrigation schedule and nitrogen levels on potato tuber yield and growth cracks. In. Intl. Symp. "Innovations in Horticulture for Nutritional Security Biodiversity and Poverty Allevation, (Oct. 16-18).

Singh RK. 2014. Management of irregular bearing in mango using paclobutrazole. In. 7th National Extension Education Congress (Nov. 08-11), ICAR Research Complex, Meghalaya.

Singh S, Singh PR, Singh AK and Gupta R. 2014. Comparative performance evaluation of sugarcane cutter planters. In. Proc. Symp. "Bioenergy for Sustainable Development-The potential role of sugar crops", (June 23-25), SBI, Coimbatore, p. 277.

Singh SN and Chauhan RS. 2014. Improving stubble buds sprouting and productivity of winter initiated ratoon in sub-tropical climatic conditions of India. In. Proc. "Intl. Conf. IS-2014: Green technologies for sustainable growth of sugar and integrated industries in developing countries", (Nov. 25-28), Nanning, P.R. China, p. 74.

Singh SN, Sah AK, Singh MR and Joshi D. 2014. Rationalizing cultural and manorial practices for enhanced productivity of good quality jaggery. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 151-152.

Singh SR, Singh I and Solomon S. 2014. Microbial deterioration of jaggery during storage and remedial measures. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow.

Sinha G, Gangwar LS and Lal N. 2014, Challenges and economic opportunities for native chickens rearing in backyard poultry system- A case study of Palamu division of Jharkhand. In. Proc. Natl. Symp. "Poultry Production for Global Trade", (Dec. 18-20), VC&RI, Namakkal.

Siraree A, Singh PK, Singh J, Kumar S and Pandey DK. 2014. DUS testing of new sugarcane (Saccharum L.) varieties- A case study. In: Proc. Natl. Symp. "Crop Improvement for Inclusive Sustainable Development (Nov. 7-9), PAU, Ludhiana, pp. 579-580.

Siraree A, Singh PK, Singh J. 2014. Gender based capacity building and hygiene for jaggery cottage units in rural India. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 176.

Sithanantham S, Thamaraichelvi C, Solomon S and Baitha A. 2014. Promoting biocontrol-based management of sugarcane borers by factory-level R&D networking: Status and scope in India. In. Proc. "Intl. Conf. IS-2014: Green technologies for sustainable growth of sugar and integrated industries in developing countries", (Nov. 25-28), Nanning, P.R. China, p. 314-320.

Solomon S and Gangwar LS. 2014. Policy initiatives and technological options for revival of jaggery and khandsari processing sector in India. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 6-12.

Srivastava AK, Shrivastava AK, Srivastava TK, Kumar V, Yadav SB and Shukla AK. 2014. Assessing impact of climate change on sugarcane jaggery. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 158-159.

Srivastava S and Pathak AD. 2014. Small RNA profiling of sugarcane under abiotic stress conditions. In: Natl. Conf. "Biotechnology & Bioengineering" (Oct. 16-17), Amity University, Lucknow.

Srivastava S and Pathak AD. 2014. Small RNA: A key player in tolerance against abiotic stresses in sugarcane. In. Intl. Symp. "Biodiversity: Status, Utilization and Impact of Challenging Climatic Conditions", (Oct. 30-31), BBAU, Lucknow, p. 231.

Srivastava S and Pathak AD. 2014. Small RNA: A key player in tolerance against abiotic stresses in sugarcane. In. Intl. Symp. "Biodiversity: Status, utilization and impact of challenging climatic conditions, (Oct. 30-31), BBAU, University, Lucknow, p. 231.

Srivastava S, Pathak AD and Kharate PK. 2014. Current states of palm jaggery. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 107-111.

Srivastava TK, Singh KP and Singh P. 2014. Growth promoting microbial consortium for wheat and sugarcane simultaneous cropping in Indian sub-tropics. In. Proc. Natl. Symp. "Agricultural Diversification for Sustainable Livelihood and Environmental Security, (Nov. 18-20), PAU, Ludhiana.

Srivastava TK, Singh KP, Singh P and Solomon S. 2014. Bio-manured multi-ratooning enhances sugarcane plant-ratoon system productivity. In. Proc. "Intl. Conf. IS-2014: Green technologies for sustainable growth of sugar and integrated industries in developing countries", (Nov. 25-28), Nanning, P.R. China, p. 56.

Swapna M, Pandey DK and Srivastava S. 2014. Commercial crosses in sugarcane: A probable source of dual purpose varieties. In. Proc. Symp. "Bioenergy for Sustainable Development: The potential role of sugar crops (June, 23-25, 2014), SBI, Coimbatore, p. 87-89.

Swapna M, Srivastava S and Pandey DK. 2014. Improving biomass in sugarcane: Dual purpose clones from commercial matings. In. Proc. "Intl. Conf. IS-2014: Green technologies for sustainable growth of sugar and integrated industries in developing countries", (Nov. 25-28), Nanning, P.R. China, p. 120.

Tripathi A, Shrivastava AK and Singh D. 2014. Diversity of seed-borne mycoflora in relation

to different chickpea varieties in Uttar Pradesh. In. Intl. Symp. "Biodiversity: Status, utilization and impact of challenging climatic conditions", (Oct. 30-31), BBAU, Lucknow, p. 226.

Verma I, Chandra A, Jain R and Solomon S. 2015. Internodal sugar and expression profiling of early and late maturing sugarcane varieties. In. Proc. 5th Intl. Conf. "Next Generation Genomics and Integrated Breeding for Crop Improvement", (Feb. 18-20), ICRISAT, Hyderabad, p. 187.

Verma R, Rajput R, Jain R and Chandra A. 2014. Nutritive value of gur and innovative recipes. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow, p. 118.

Verma RR, Singh RK and Singh SR. 2014. Human nutritional and livelihood security through modernization of sugarcane jaggery industry. In. Proc. Natl. Meet "Modernization of Jaggery Industry in India" (Nov. 1-2), IISR, Lucknow.

Zubair A, Singh GK and Kumar R. 2014. Sinchai jal upayog daksh takneek dwara ganna utpadan. In. "15th Rashtriya Krishi Vigyan Sangosthi", (Dec. 5-7), Rajmata Vijayaraje Sindhiya Krishi Vishwaviddyalaya, Gwalior, p. 37.

Extension Folder

Hasan SS, Baitha A, Singh MR, Sah AK, Shukla SK and Kumar R. 2015. CaneDes: An Expert System for Diagnosis in sugarcane crop. Extension Brochure, IISR, Lucknow.

15

Technical programme (2014-15)

Project No.	Name of the project	Investigators, duration, budget, funding agency
	Division of Crop Improvement	
B 1.7	Collection, maintenance, evaluation and documentation of sugarcane germplasm under sub-tropical conditions	P.K. Singh, Sanjeev Kumar, J. Singh; 01/1995-LT
B 2.3	Development of sugarcane breeding stocks for high sugar	Raman Kapur, S.K. Duttamajumder; 11/1993-3/2016
B 2.9	Development of top borer tolerant genetic stocks of sugarcane	A.D. Pathak, R.K. Rai, Sangeeta Srivastava, M.R. Singh, Rajesh Kumar; 3/2000-10/2018
B 2.13	Development of sugarcane varieties for sub-tropics	J. Singh, D.K. Pandey, P.K. Singh, Sanjeev Kumar, R.K. Singh, T.K. Srivastava; 10/2003-LT
B 2.14	Development of breeding stocks of sugarcane for durable resistance to red rot	D.K. Pandey, P.K. Singh, Sunita Lal, J. Singh, Sanjeev Kumar; 10/2004-03/2017
B 2.15	Developing sugarbeet varieties for Indian agro-climates	A.D. Pathak, Raman Kapur, S.K. Duttamajumder, Arun Baitha; 09/2008- LT
B 3.17	Elucidation of species chromosomal complement in sugarcane genotypes under sub-tropical conditions	Sangeeta Srivastava, A.D. Pathak; 06/2010-05/2018
B 3.18	Identification and expression analysis of resistance gene analogues against red rot disease in sugarcane	Sangeeta Srivastava, Ramji Lal, R.K. Singh, M. Swapna; 01/2010-3/2018
B 3.19	Mapping of loci linked to sugar content in sugarcane	M. Swapna, Sangeeta Srivastava, D.K. Pandey; 12/2009-03/2020
B 3.20	Identification and validation of molecular markers for red rot resistance in sugarcane	R.K. Singh, Sunita Lal, D.K. Pandey; 04/2015-04/2018
B 3.21	Production of disease-free and genetically pure seed cane through tissue culture techniques	R.K. Singh, Sanjeev Kumar, J. Singh; 2011-LT
Bm 2.16	Development of waterlogging tolerant and red-rot resistant sugarcane clones for North Central Zone	Sanjeev Kumar, Ramji Lal; 2012-2015
	AICRP on Sugarcane	
B 1.1	Evaluation of early maturing sugarcane clones of North West Zone	J. Singh, D.K. Pandey; 02/2009 - LT
B 1.2	Evaluation of mid-late sugarcane clones of North West Zone	Sanjeev Kumar, P.K. Singh; 02/2009 to LT
B 1(M)	Evaluation of sugarcane clones under Zonal Varietal Trials for North Central and Eastern Zone	Sanjeev Kumar (Up to 31.12.2014), A.D. Pathak; 02/2009 to LT

Project No.	Name of the project	Investigators, duration, budget, funding agency
	Externally funded project	
DBT	RNA seq for SNP mining and linkage mapping in sugarcane	Nandita Banerjee, Sanjeev Kumar, RK Singh; 2014-2017; ₹ 45.85 lakh (DBT, New Delhi)
DBT	Accredited Test Laboratory (ATL) under National Certification System for Tissue Culture Raised Plants	Coordinator: R.K. Singh PIs: Sanjeev Kumar, S.K. Holkar; 2015-2018, ₹ 65.0 lakh (DBT, New Delhi)
N P T C - 3087	Network project on Transgenics in crops (NPTC)	R.K. Singh, Sanjeev Kumar; 2015-2017; ₹ 98.49 lakh (ICAR, New Delhi)
PPV& FRA	Central Sector Scheme for PPV&FRA	J. Singh, P.K. Singh; 2006-LT (PPV & FRA, New Delhi)
ICAR	ICAR Seed Project "Seed production in agricultural crops"	Sanjeev Kumar, P.K. Singh; 2012-2017 (ICAR, New Delhi)
	Division of Crop Production	
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, Rajendra Gupta; 03/2012-03/2016
A 1.1.30	Yield maximization through optimizing shoot population density	T.K. Srivastava, A.K. Singh, Ishwar Singh; 02/2012-03/2015
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, A.K. Sah; 01/2012-12/2015
ET 1.13	Assessment of sugarcane cultivation machines (RMD and RBS-cum planter) on farmers' field	A.K. Sah, Akhilesh K. Singh, Kamta Prasad, R.K. Singh; 09/2012-09/2015
ET 1.14	Entrepreneurship development for sugarcane seed production and multiplication	A.K. Sah, S.N. Singh, Sanjeev Kumar, Ram Ji Lal, S.N. Sushil, Kamta Prasad; 10/2012-10/2016
A 2.35	Assessment of soil fertility status of sugar mill command areas of sub-tropical India	T.K.Srivastava, K.P.Singh, R.R. Verma, R.K. Singh; 03/2012-04/2014
A 2.36	Assessing nutrient interactions for sustaining sugarcane productivity and soil health	R.R.Verma, Ishwar Singh, R.K. Rai; 02/2013-03/2016
A 1.2.30	Rationalizing irrigation water use in sugarcane through optimizing field application parameters	Rajendra Gupta, A.K. Singh, Pushpa Singh; 11/2012-10/2014
	AICRP (S) trial	
AS 42	Agronomic evaluation of promising genotypes of sugarcane	S.R. Singh, S.K. Shukla; LT
AS 64	Response of sugarcane crop to different plant nutrients in varied agro-ecological situations	C. Gupta, S.N. Singh, S.K. Shukla, A.K. Singh; 2011-2015
AS 65	Enhancing sugarcane productivity and profitability under wheat-sugarcane cropping system	Ishwar Singh, S.N. Singh; 10/2012-06/2015
AS 66	Priming of cane node for accelerating germination	S.N. Singh, T.K. Srivastava; 2012-2015
AS 67	Optimization of fertigation schedule for sugarcane through micro-irrigation technique under different agro-climatic conditions	Rajendra Gupta, S.K. Shukla, C. Gupta; 2012-2015
STCR	Soil test and resource based integrated plant nutrient supply system for sustainable sugarcane production	S.R. Singh, T.K. Srivastava, R.R. Verma, S.S. Hasan; 2014-onwards

Project No.	Name of the project	Investigators, duration, budget, finding agency
	Externally funded project	
DST	Carbon sequestration potential of sugarcane based cropping system for sustaining crop health and crop productivity in Uttar Pradesh	S.K. Shukla, T.K. Srivastava, Pushpa Singh, R.K. Rai, P.K. Bajpai; 2012-2015, ₹67.204 lakh (DST, New Delhi)
UPCAR	Evaluation of microbial mapping and their correlation on productivity, plant and soil health in maor cropping sytems of Uttar Pradesh	S.R. Singh, SK Shukla, Dinesh Singh, Sanjeev Kumar; 2014-2017, ₹ 17.963 lakh (UPCAR, Lucknow)
UPCAR	Evaluation of new herbicide for major sugar crops with special reference to sugarbeet in relation to weed dynamics, control efficiency and sugar productivity	A.K. Singh; 2014-2017; ₹ 14.993 lakh (UPCAR, Lucknow)
	Contract research	
DF & PCCL	Studies on the effect of Zinc bensulf on yield and quality of sugarcane	R.R. Verma, S. Solomon, S.N. Singh; 2013-2015; ₹6.0 lakh (DF&PCCL)
CSMCRI	Response of seaweed saps and potassic fertilizer in sugarcane yield	Ishwar Singh; 03/2015-03/2016; ₹ 5.0 lakh (CSMCRI, Bhavnagar)
Prasmo Agri	Effect of deep gel and nutrisap on growth, yield and quality of sugarcane and soil health in subtropical India	S.K. Shukla, S. Solomon, S.N. Singh; 2013-2015; ₹1.0 lakh (Prasmo Agri)
IPM Labs	Biocontrol testing of biofertilizer 'Hi-brix' in sugarcane	S.K. Shukla, S. Solomon, S.N. Singh; 2013-2015, ₹ 5.0 lakh (IPM Labs Pvt. Ltd.)
Bayer	Assesing bioefficacy of Imidacloprid 40% + Fipronil 40%-80WG against white grub, termite and shoot borer and its impact on cane yield and sugar recovery	S.N. Singh, M.R. Singh; 2014-17, ₹ 7.0 lakh (Bayer Crop Sciences)
	Division of Crop Protection	
M15.6	Enhancing efficacy of *Trichoderma* based red rot management system	Deeksha Joshi, A.K. Singh, Pushpa Singh; 04/2012-03/2017
M15.7	Mass multiplication of *Trichoderma* on cheaper substrates and development of suitable delivery system for disease management in sugarcane	A.K. Singh and Deeksha Joshi; 04/2012-03/2017
M17	Evaluation/screening of sugarcane germplam/genotypes against red rot and smut	S.K. Duttamajumder and Ram Ji Lal; 1992-93 to LT
M20.1	Genome sequencing of red rot pathogen	S.K.Duttamajumder, Amaresh Chandra, R.K.Singh, Deeksha Joshi, Nithya, K.; 09/2012-02/2017
EM01	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; 04/2006-LT
Ento 15.1	Containment of major insect-pests of sugarcane through habitat modifications	Arun Baitha and M.R. Singh; 04/2012 - 03/2017
Ento 15.2	Semiochemicals for the management of sugarcane top borer	M.R. Singh, Arun Baitha; 03/2012-02/2017
Ento 2.1	Mechanism of resistance against top borer in sugarcane	M.R. Singh, A. Chandra, A.D. Pathak; 04/2012-03/2017
Ento 11.2	Development of techniques of mass multiplication of larval parasitoids for management of sugarcane top borer	Arun Baitha, M.R. Singh; 04/2012-03/2017

Project No.	Name of the project	Investigators, duration, budget, finding agency
	AICRP (S) trial	
PP 14	Identification of pathotypes in red rot pathogen	Ramji Lal, S.K. Dattamajumder; 2002-LT
PP 17	Evaluation of varieties/genotypes against red rot, smut, wilt and yellow leaf disease	S.K. Dattamajumder, Ramji Lal; 1984-LT
PP 22	Survey of sugarcane diseases naturally occurring in the area on important varieties	Ramji Lal; LT
E 28	Survey and surveillance of sugarcane insect pests	Ramji Lal and all the scientists of the Division; LT
E 30	Monitoring of insect pests and bioagents in sugarcane agro-eco system	M.R. Singh; LT
E 34	Standardization of simple and cost-effective techniques for mass multiplication of sugarcane bio-agent	M.R. Singh; 03/14-LT
E 36	Management of borer complex of sugarcane through lures	M.R. Singh; 2009-LT
E 4.1	Evaluation of varieties/genotypes for their reaction against insect pests	M.R. Singh; 2014-LT
	Externally funded project	
ICAR	Studies on rhizospheric microbial diversity in relation to different sugar profile varieties for growth promotion and disease management	Dinesh Singh, Ramji Lal, S.R. Singh; 2014-2017; ₹ 20.0 lakh (ICAR, New Delhi)
	Contract research	
FMC	Bio-efficacy testing of FMC (I) 113 against termites in sugarcane	Arun Baitha, Ram Ji Lal, S. Solomon, S.K. Shukla; 2014-2016; ₹ 7.5 lakh (FMC India Ltd.)
DuPont	Bioefficacy testing of chlorantraniliprole 35 WG (Rynaxupyr) against top, stalk and internodes borer in sugarcane	Arun Baitha, S.K. Duttamajumder, S. Solomon; 2013-2015; ₹ 10.0 lakh (DuPont India Pvt. Ltd.)
Bayer	Bioefficacy of Fipronil 0.6 GR against ESB and termites in sugarcane	Arun Baitha, S.K. Duttamajumder, S. Solomon; 2013-2015; ₹ 5.0 lakh (Bayer Crop Science)
UPL	Evaluation of efficacy of Lancergold (Acephate 50% + Imidacloprid 18% SP) against black bug, early shoot borer, white grub and termite	Arun Baitha, Ram Ji Lal, S.K. Shukla, S. Solomon; 2014-2016; ₹ 2.0 lakh (United Phosphorus Ltd.)
	Division of Plant Physiology and Biochemistry	
PB 23	Optimization of plant population for improving physiological efficiency of sugarcane	R.K. Rai, A.K. Shrivastava, R. Banerji, A. Chandra, Pushpa Singh, S. Solomon and Radha Jain; 02/2010-03/2017
PB 24	Modulating the expression of sucrose metabolizing enzymes for high sucrose accumulation in sugarcane	Radha Jain and A. Chandra; 10/2009-03/2017

Project No.	Name of the project	Investigators, duration, budget, finding agency
PB 26	Developing a technology for preservation & packaging of sugarcane juice	A. Chandra and S.I. Anwar; 04/2012-03/2015
PB 27	Molecular study to reveal transcriptomes and genes associated with sucrose (GAS) transport and accumulation in sugar	A. Chandra, Radha Jain and S. Solomon; 04/2012-03/2017
PB 28	Minimizing post-harvest sucrose deterioration and its molecular assessment	S. Solomon, A. Chandra and Radha Jain; 04/2012-03/2017
	Screening and identification of sugarcane lines tolerant to waterlogging and their physio-biochemical investigation	Radha Jain, A. Chandra, A.D. Pathak, M. Swapna, D. Kumar, V. Singh, V.K. Srivastava and R. Ramadurai; 2013-2018
	Externally funded project	
DST	Functional genomic analysis of differential accumulation of sucrose targeting genes of invertase, sucrose synthase and sucrose phosphate synthase and their impact on source-sink relationships in sugarcane	A. Chandra, R. Jain; 2013-2016; ₹ 20.0 lakh (DST, New Delhi)
DST	Down regulation of soluble acid invertase SAI gene to minimize post-harvest sucrose loss through RNAi technology in sugarcane (*Saccharum sps. Hybrid)*	Amita Sharma, Mentor: A. Chandra (DST-Women Scientist DST, New Delhi)
CSTUP	Enhancing sugarcane bioproductivity: physiological and metabolic interventions using nutrient-hormonal carriers	Radha Jain, A. Chandra; ₹ 9.0 lakh; 2015-18 (CST UP, Lucknow)
	Contract research	
Privi Life Sciences	Effect of silica granules on growth, yield and juice quality parameters of sugarcane	Radha Jain, S.K. Shukla and S. Solomon; 2013-15; ₹ 5.0 lakh (Privi Life Sciences Pvt. Ltd., Navi Mumbai)
Biodeg Chemical	Effect of Biodeg products on biochemical attributes, cane yield and juice quality of sugarcane	Radha Jain, A. Chandra, S.K. Shukla, S. Solomon; 2014-16; ₹ 3.0 lakh (Biodeg Chemical & Allied Industry & Kemtech Polymers, New Delhi)
Privi Life Sciences	Effect of Silixol on growth, yield and juice quality attributes of sugarcane	Radha Jain, A. Chandra, S.K. Shukla, S. Solomon; 2014-16; ₹ 5.0 lakh (Privi Life Sciences Pvt. Ltd., Navi Mumbai)
Cytozyme Labs	Effect of Cytozyme (USA) products on growth, yield and quality of sugarcane	A.K. Shrivastava, Pushpa Singh, SP Shukla, CP Prajapati, 2015-17, ₹ 10.0 lakh (Cytozyme Labs, Gurgaon)
	Division of Agricultural Engineering	
AE 9.1	Design refinement of sugarcane-cum-potato planter	P.R. Singh, Rajendra Gupta, A.K. Singh; 07/2012-06/15
AE 1.51	Development of tractor operated sugarcane manager	P.R. Singh, A.K. Singh, Rajendra Gupta; 04/2012-12/14
AE 1.9F	Development of sugarcane harvester for small farms	A.K. Singh, P.R. Singh; 03/2012-02/16
AE 1.22E	Development of modified furrower type sugarcane planter	A.K. Singh, R.D. Singh; 03/2015-03/18

Project No.	Name of the project	Investigators, duration, budget, funding agency
	AICRP on FIM	
Prototype manufacturing workshop	Manufacturing of prototypes for conducting multilocation trials	A.K. Singh, P.R. Singh; 04/1986-LT
Front-line demonstration (FLD)	IISR tractor operated ratoon management device (RMD)	A.K. Singh, P.R. Singh; 04/2013- 03/15
	IISR tractor operated raised bed seeder-cum-sugarcane planter	A.K. Singh, P.R.Singh; 05/2013-04/15
	IISR tractor operated three row sugarcane planter	A.K. Singh, P.R. Singh; 04/2013– 03/15
	IISR tractor operated paired row sugarcane planter	A.K. Singh, P.R. Singh; 10/2011 - 09/15
	Jaggery Unit	
AE 7.6.2	Development of a jaggery furnace with efficiency boosting device	S.I. Anwar, P.R. Singh; 04/2012-03/17
AE 7.6.3	Optimization of parameters for shelf-life enhancement of jaggery under modified atmosphere packaging	Dilip Kumar; 04/2012-03/15
	AICRP on Post-harvest Technology	
LKO/ PHTS/ 08/1	Evaluation of shrink wrap, stretch wrap and modified atmosphere packaging for storage of jaggery cubes and blocks	R.D. Singh, S.I. Anwar; 12/2006-03/13
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, R.D. Singh; 04/2011-03/15
LKO/ PHTS/ 11/02	Refinement of juice extraction process with special reference to sugarcane cleaning and juice filtration for 100 kg jaggery/8 h	S.I. Anwar, R.D. Singh; 04/2011-03/15
LKO/ PHTS/ 11/03	Development/adoption of evaporator for sugarcane juice	R.D. Singh, S.I. Anwar; 04/2011-03/15
LKO/ PHTS/ 11/04	Development of power operated jaggery moulding machine	Dilip Kumar, R.D. Singh, S.I. Anwar; 04/2011-03/15
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, R.D. Singh; 04/2011-03/15
LKO/ PHTS/ 12/01	Optimization of parameters for shelf-life enhancement of jaggery under modified atmosphere packaging	Dilip Kumar; 04/2012-03/15
LKO/ PHTS/ 14/01	Value-addition of jaggery with Indian spices and herbs for increased market value	S.I. Anwar, Dilip Kumar, 11/2014-10/16

Project No.	Name of the project	Investigators, duration, budget, funding agency
LKO/ PHTS/ 14/02	Development of a semi-automatic jaggery manufacturing plant	Dilip Kumar, Prasoon Verma, S.I. Anwar, G.S. Nevkar, P.V.K.J. Rao: 04/2014-03/17
	Externally funded project	
LKO/ PHTS/ 13/1	Assessment of post-harvest losses in major crops and commodities in India	Dilip Kumar, S.I. Anwar, R.D. Singh; 04/2012-03/15 (Ministry of Food Processing Industries, Govt. of India)
LKO/ PHTS/ 13/02	Study on determining on storage losses in food grains in FCI and CWC warehouses and to recommend norms for storage losses in efficient warehouses	Dilip Kumar, S.I. Anwar, 01/2013-12/16 (ICAR/FCI, New Delhi)
	Agrometeorology	
AM 5	Impact of climate change on sugarcane insect-pests dynamics and behaviour	M.R. Singh, Rajesh Kumar; 04/2012-03/16
	Externally funded project	
ICAR	Assessment of Impact of climate change on productivity and quality of sugarcane and opportunities of adaptation (under NICRA)	A.K. Shrivastava, TK Srivastava; 04/2013-04/17 (ICAR New Delhi)
	Agriculture Knowledge Management Unit (AKMU)	
AES 4.12	Developing efficient sugarcane marketing strategies in India	A.K. Sharma, M.R. Verma; 04/2010-09/14
AES 4.14	Geographic information system of sugarcane and sugar in India	Rajesh Kumar, S.S. Hasan, P.K. Bajpai; 03/2012 – 03/17
AES 4.15	Development of data mining and presentation tools in sugarcane	S.S. Hasan, P.K. Bajpai Rajesh Kumar, L.S. Gangwar; 04/2012 –03/18
AES 4.16	Estimation of optimum sample size for evaluation and prediction of cross-performance	P.K. Bajpai, J. Singh, Rajesh Kumar, S.S. Hasan; 03/2012-02/15

16

Research evaluation committees

Research Advisory Committee Meeting

The XX meeting of Research Advisory Committee (RAC) of the Indian Institute of Sugarcane Research, Lucknow for the year 2014 was held on May 28-29, 2014 under the chairmanship of Dr. A.N. Mukhopadhyay, Former Vice Chancellor, AAU, Jorhat. Dr. D.G. Hapse, 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., Harinagar, West Champaran, Bihar, Sh. K.S. Rathi, Farmer Representative and Non-official member and Dr. S. Solomon, Director, IISR, Lucknow were other members who were present during the meeting. Dr. S. Solomon, Director, IISR presented an overview of the R & D activities carried out by the Institute during the last year, with a brief about the present sugar scenario in the country. Dr. T.K. Srivastava, Head, Division of Crop Production made a presentation on IISR efforts for enhancing sugarcane productivity in sub-tropical region. He appraised the house that a large-scale yield maximization was conducted at IISR farm, incorporating the various technological interventions from IISR, and the aim to achieve a cane yield of ~100 t/ha was fulfilled. The HoDs/programme leaders presented the action taken report on the recommendations of last RAC.

The representative from sugar industry, Mr. J.L. Jain, General Manager (Cane), Harinagar Sugar Mill, and the non-official member of RAC and Shri K.S. Rathi appraised about the concern of the sugar mills and farmers in Bihar and UP, respectively. Dr. D.G. Hapse, Member, RAC made a presentation on the sugar scenario in the country, constraints in dwindling per hectare cane yield and cane quality. He also suggested to integrate research in areas of enhancing root growth, improvement in root functioning and activities, synchronous tillering and improvement in tiller survival, studies in fertigation and yield improvement under water stress as well as waterlogged conditions.

Dr. A.K. Sharma, I/c, PME Cell gave an overview of the activities of Prioritization, Monitoring and Evaluation (PME) Cell at IISR, information about Institute Results Framework Document (RFD), Citizen Charter, the QRT (2005-09) recommendations and RAC. The Committee gave following recommendations which were approved by the council:

1. Research efforts in the crop production and management should be directed towards reducing cost of cultivation, particularly on seed, fertilizers, interculture, moisture conservation and weed management.
2. Cane node technology may be further refined and seed priming may include efficient strains of *Trichoderma* and *Gluconoacetobactor*. A cane node planter may be developed and tested for economic evaluation.
3. Large-scale technology demonstrations on cane node, STP and bud chip method in plant crop and multiple ratoons may be conducted in association with the sugar mills and KVKs on farmers' fields in Uttar Pradesh and other states.

4. Breeding for high biomass energy cane may be initiated for co- generation/ethanol production.
5. Possibilities of semi-commercial scale trials may be explored for processing of sugarbeet in sugar mills with diffusion facilities.
6. Status of insect pests and diseases may be assessed in a systematic manner in different states in subtropics in association with sugar mills and SAUs. A map of important diseases and insect pests may be developed.
7. Work on sugarcane yellow leaf disease and sugarcane mosaic disease be initiated/carried out in collaboration with IARI/UPCSR/SBI.
8. A time bound project on mass multiplication of *Trichoderma* be carried out.
9. An awareness programme be conducted on the proper use of MHAT for the cane Managers, CDOs and progressive farmers from U.P., Bihar, Odisha, M.P. and Uttarakhand.
10. Sugar mills may be encouraged and advised to establish their own biocontrol laboratories
11. A PGR-nutrient based technology be developed to stabilize plant population and minimize tiller mortality in sugarcane.
12. The physiological efficiency of ratoon crop needs to be enhanced to get better economic return.
13. Refinement of sugarcane planters and its commercialization through reputed manufacturers may be carried out.
14. Sugarcane cutter planter + potato planter be popularized in Bihar.
15. Field days (3-4 days) on sugarcane mechanization may be conducted in major sugarcane growing areas.
16. Efforts may be made to assess the impact of sugarcane machines on adoption by cane growers.
17. The research activities may be prioritized and the number of research projects be reduced. Core Programmes may be adhered to.
18. Feedback may be obtained from growers on the performance of important technologies.
19. IISR Regional Center at Motipur should be strengthened and work on waterlogging and red rot tolerant varieties should be taken up.
20. Bio-fertilizer unit be made more productive. Also accreditation of tissue culture lab be obtained from DST/Govt. of India.
21. Consolidate all important technologies developed by the Institute and publish in a book form.

Institute Research Council Meeting

Two meetings of the Institute Research Council (IRC) were organized during the year 2014-15. The first meeting was held under the Chairmanship of Dr. S. Solomon, Director, IISR on July 23-25, 2014. The Chairman gave a brief account of the important challenges faced in sub-tropical region with respect to sugarcane cultivation. He emphasized that, IISR being a national institute, the productivity enhancement for sugarcane is the responsibility of this Institute. He added that our efforts towards this direction in the form of yield maximization trials being conducted for the last two years is a success as we have been able to achieve our target of 100 t/ha without any cost escalation. The Chairman also stressed upon the need for outreach programmes on a larger-scale and informed the house about the various initiatives in this direction, *viz.*, quality seed programme, development of soil maps and soil health cards for different states of sub-tropical India. Action Taken Report on the recommendations of IRC meeting was presented by the respective HoDs. Three research outputs, *viz.*, Cane node technology for saving of seed cane and higher sugarcane yield, residue recycling along with *Trichoderma* in sugarcane production system for enhanced soil health, carbon sequestration and cane productivity and CaneDES were identified for its further development as technology for dissemination/ commercialization.

The research work and activities of IISR Regional Centre, Motipur, & Sugarbeet Breeding Outpost, Mukteswar and IISR Biological Control Centre, Pravaranagar was also reviewed. The Chairman reviewed all the 62 Institute on-going research projects/activities. A special session of IRC under the Chairmanship of the Director was also organized at IIRS Regional Centre, Motipur, Bihar on Sept. 25, 2014 and five new research project proposals were discussed.

The second IRC meeting was held under the Chairmanship of Dr. O.K. Sinha, Director, IISR in four sessions on March 16, 17, 19 and 31, 2015. The agenda for the meeting was to review the progress on the research project proposals taken up for consideration in the previous IRC meeting as well as to review the new project proposals to be initiated before the planting season 2015-16. Ten new research projects and two contract projects were discussed and approved. Extension was also given to 11 on-going Institute projects.

Quinquennial Review Team

The Council has constituted the Quinquennial Review Team (QRT) comprising of following members 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.

Institute Management Committee Meeting

The 37th Meeting of Institute Management Committee of the Institute was held at IISR Regional Centre, Motipur, Bihar on Sept. 25, 2014 under the chairmanship of Dr. S. Solomon, Director, IISR, while 38th Meeting of IMC was held at IISR, Lucknow on March 13, 2015 under the chairmanship of Dr. O.K. Sinha, Director, IISR. The progress of the various Divisions/Sections of the Institute was reviewed in the meeting and various agenda items related to Administration and Finance were discussed.

Quinquennial Review Team

1.	Dr. J.B. Chaudhary, Ex Vice Chancellor, GBPUA&T, Pantnagar	Chairman
2.	Dr. N. Vijayan Nair, Ex Director, Sugarcane Breeding Institute, Coimbatore	Member
3.	Dr. D.C. Uprety, Ex National Fellow, IARI, New Delhi	Member
4.	Dr. Menhi Lal, Ex Head, Division of Crop Production, Indian Institute of Sugarcane Research, Lucknow	Member
5.	Dr. Bacchan Singh, Ex Professor, Agril. Engineering, GBPUA&T, Pantnagar	Member
6.	Dr. Satyavir, Ex Dean (Agriculture), CCSHAU, Hisar	Member
7.	Dr. R.K. Samantha, Ex Director, MANAGE & NAARM, Hyderabad	Member
8.	Dr. T.K. Srivastava, Head, Division of Crop Production, Indian Institute of Sugarcane Research, Lucknow	Member Secretary

Institute Technology Management Committee

The meeting of Institute Technology Management Committee was held on November 20, 2014 under the chairmanship of Dr. S. Solomon, Director, IISR, Lucknow. The other officials present in the meeting were Dr. O.K. Sinha, Project Coordinator (Sugarcane), Dr. S.N. Singh, Principal Scientist, Dr. P.R. Singh, HoD (Agril. Engg.), Dr. Amaresh Chandra, HoD (PPB), Dr. Sangeeta Srivastava, Principal Scientist, Dr. S.K. Shukla, Pr. Scientist & I/c BPD Unit, Dr. M. Swapna, Sr. Scientist, Mr. Ratnesh Kumar, SAO, Sh. Raja Ram, F&AO and Dr. A.K.

Sharma, Pr. Scientist and Nodal Officer, ITMU. The matter pertaining to the costing/pricing of Institute technologies/publications were discussed. The guidelines for Post-Doctoral Fellow (PDF) at IISR, Lucknow and encouraging business promotion activities at IISR were discussed in the meeting.

Institute Bio-safety Committee Meeting

Institute Bio-safety Committee (IBSC) meeting was held on December 15, 2014 under the chairmanship of Dr. S. Solomon, Director of the Institute. Various steps regarding biosafety involved in the experimentation was discussed. The meeting was attended by Dr. S. Solomon, Dr. Neelam Sangwan (DBT nominee), Dr. Amresh Chandra (internal expert), Dr. Sangeeta Srivastava (internal expert), Dr.

S.K. Sethi (Medical Officer), and Dr. Swapna M. (member secretary). Dr. S.K. Dattamajumder, Dr. R.K. Singh, Dr. Sanjeev Kumar, and Dr. A.K. Sharma attended the meeting as special invitee.

Results-Framework Document (RFD)

Annual Performance Evaluation Report in respect of RFD 2013-2014 of RSCs *i.e.*, Institutes

Division : **Crop Science**
Institute/RSC : **Indian Institute of Sugarcane Research, Lucknow**
RFD Nodal Officer at RSC : **Dr. A.K. Sharma**

Sl	Objective	Weight (%)	Action	Success Indicator	Unit	Weight (%)	Target/Criteria value					Consolidated achievements	Performance		% achieve-ments of 90% Col.*	Reasons for excess or shortage
							Exlt	VGd	Gd	Fr	Pr					
							100%	90%	80%	70%	60%		Raw score	Weighted Score		
1	To develop efficient, eco-friendly sugarcane crop manage-ment practices/ tools to attain high sugarcane and sugar productivity.	41	Development and identification of efficient/appropriate crop production and protection practices.	Agro techniques/ technologies/ methods/ formulations developed/ identified/tested	No.	30	10	5	3	2	1	5	90%	27	100	-
			Development/ improvement of equipment/ machinery for sugarcane cultivation	Prototypes designed/ fabricated and prototype feasibility tests carried out	No.	11	20	10	6	3	1	10	90%	9.9	100	_
2	To develop high yielding, high sugar, biotic and abiotic stress tolerant sugarcane and sugar beet varieties.	28	Evaluation of genetic material	Number of genotypes and elite clones evaluated for desirable traits	No.	9	220	200	100	50	25	200	90%	8.1	100	-
			Development of improved varieties/cultivars.	Entries contributed for AICRP multilocation trial	No.	3	50	40	30	20	10	89	100%	3	222.5	See "A" below
				New varieties identified for release	No.	10	4	3	2	1	0	5	100%	10	166.7	See "B" Below
			Seed production programme	Truthfully labelled seed cane produced	00 tonne	6	12	9	6	4	2	8	86.6	5.2	88.8	-
3	To provide training, consultancy and advisory	20	Capacity building/ training and demonstrations and new and	Farmers'/extension officials training programmes organized	No.	8	10	8	6	4	2	10	100%	8	125	Due to more number of sponsored training programmes

	services to stake-holders		existing technologies	Demand based surveys conducted and advisory services provided to stakeholders/industry	No.	8	10	5	3	2	1	11	100%	8	220	Due to more demands for surveys and advisory services from the sugar mills
				Frontline/ on-farm demonstrations conducted	No.	4	70	60	40	20	10	82	100%	4	136.7	Due to more number of equipment/ machinery demons-trations
4	Efficient functioning of the RFD system	3	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	2.00	15/05/2013	16/05/2013	17/05/2013	20/05/2013	21/05/2013	15/05/2013	100%	2	100	-
			Timely submission of Results for RFD (2012-13)	On-time submission	Date	1.00	01/05/2013	02/05/2013	05/05/2013	06/05/2013	07/05/2013	01/05/2013	100%	1		-
5	Administra-tive reforms	4	Implement ISO 9001 as per the approved action plan	% implementation	%	2.00	100	95	90	85	80	0	0	0	0	-
			Prepare an action plan for Innovation	On- time submission	Date	2.00	30/07/2013	10/08/'2013	20/08/'2013	30/08/2013	10/09/2013	04/11/2013	-	0	-	-
6	Improving internal improving internal efficiency/ responsive-ness / service delivery of Ministry / Departmen t	4	Implementation of Sevottam	Independent audit of implementation of Citizen's Charter	%	2.00	100	95	90	85	80	100%	100%	2	105	-
				Independent Audit of implementation of public grievance redressal system	%	2.00	100	95	90	85	80	100%	100%	2		-
			Total composite score											**90.2**		
			Rating											**Very Good**		

A. Achievement of 89 entries contributed to AICRP multilocation testing is inclusive of IISR as well as all AICRP Centres. The value may increase or decrease considerably on year to year basis depending upon the performance of entries on account of climatic and biological factors.

B. The identification of the varieties for release depends upon the proposals submitted by different AICRP Centres and the decision of the Varietal Identification Committee in AICRP on Sugarcane Workshop (Exogenous factors).

17

Participation of officials in conference/workshops/ seminar/symposia

Name of the official	Name of the conference	Organised at	Date
TK Srivastava	Brain Storming Session on Potential of Modern tools for Improving the Productivity of Agricultural Crops	UPCAR, Lucknow	May 05, 2014
AK Singh, SR Singh, AK Sharma, Chandra Gupta, Brahm Prakash	2nd UP Agricultural Science Congress	IISR, Lucknow	June 14-16, 2014
TK Srivastava, AK Singh, Ram Ji Lal, LS Gangwar, ArunBaitha	IISR-Industry Interface on Enhancing Sugar Productivity in Uttarakhand	IISR Sugar beet Breeding Outpost, Mukteshwar	July 03-04, 2014
PK Bajpai, SS Hasan	International Conference on Modeling and Computing – 2014 (ICMC-2014)	BBAU, Lucknow	July 10-11, 2014
SS Hasan	International Symposium on Advances in Biological & Material Sciences	University of Lucknow	July 15, 2014
SS Hasan	National Seminar on Diminishing Sugarcane Productivity & Sugar Recovery in Northern India: Opportunities and Challenges	Lucknow	July 18, 2014
AK Singh	All India Seminar on Appropriate Farm Mechanization for Small and Marginal Farmers	Kolkata	Aug. 08-09, 2014
Ram K Singh	Joint Meeting of The American Phytopathological Society (APS) - Canadian Phytopathological Society (CPS)	Minneapolis, Minnesota, USA	Aug. 9-13, 2014
Deepak Rai	Midterm Review Workshop of KVKs	ZPD unit Kanpur	Aug. 26-27, 2014
SS Hasan, AK Sah	73rd Annual Convention of STAI	NIMHANS, Bangaluru	Sept. 9-11, 2014
PR Singh, AK Singh, Ram Ji Lal, Rajendra Gupta	Mechanization Day	Harinagar Sugar Mill, Harinagar	Sep. 26, 2014
SN Singh	KVK Zone-IV Worksop on Technological Interventions for Enhancing Sugarcane Productivity in Uttar Pradesh and Uttarakhand through KVKs	IISR, Lucknow	Sept. 29, 2014
A.K. Sharma	Unit Cost Committee Meeting at Cane Commissioner Office	Patna, Bihar	Sept. 30, 2014
RK Rai, Pushpa Singh	2nd Annual Convention of Bhartiya Sugar	Kolhapur	Oct. 13-14, 2014
Ram Ji Lal MR Singh	*Kishan Gosthi*	Hasanpur Sugar Mill, Hasanpur	Oct. 16, 2014
Sangeeta Srivastava	National Conference on Biotechnology & Bioengineering	Amity University, Lucknow	Oct. 16-17, 2014

Name of the official	Name of the conference	Organised at	Date
Deeksha Joshi	International Symposium on "Innovations in Horticulture for Improving Nutritional Security, Conserving Biodiversity and Poverty Alleviation	BBAU, Lucknow	Oct. 16-18, 2014
PK Singh	Conference of Improvement in Quality and Standard of in-house Magazines	New Delhi	Oct. 21, 2014
Sangeeta Srivastava	International Symposium on Biodiversity: Status, Utilization and Impact of Challenging Climatic Conditions	BBAU, Lucknow	Oct. 30-31, 2014
TK Srivastava, SK Shukla, AK Singh, SN Singh, Ram Ji Lal, MR Singh, ArunBaitha, Dinesh Singh	30th Biennial workshop of All India Coordinated Workshop on Sugarcane	IISR, Lucknow	Nov. 01-02, 2014
All the scientists	National Meet on Modernization of Jaggery Producton and Jaggery Carnival	IISR, Lucknow	1-2 Nov, 2014
J Singh, PK Singh	National Symposium on Crop Improvement for Inclusive Sustainable Development	PAU, Ludhiana	Nov. 7-9, 2014
RK Singh	National Extension Education Congress	ICAR research Complex, ghalya	9-11 Nov. 2014
GK Singh Adil Zubair	National Seminar on Climate Resilient Forage Production and its Utilization	BCKV, Kalyani	Nov. 13-14, 2014
PK Singh	Workshop on Capacity Building of the Implementation of ITPGRFA in India	Deendayal Research Institute, Chitrakoot	Nov. 17-18, 2014
TK Srivastava, SK Shukla,	National symposium on Agricultural Diversification for Sustainable Livelihood and Environment Security	PAU, Ludhiana	Nov 18-20, 2014
AK Singh Sanjeev Kumar	Communication Workshop on Agricultural Biotechnology	DBT/BCIL, New Delhi	Nov. 18-20, 2014
LS Gangwar	22nd Annual ERA Conference	UAS, Raichur	Nov. 18-20, 2014
RR Verma	National Seminar on Developments in Soil Science 2014 in 79th Annual Convention of Soil Science	ANGRAU, Hyderabad	Nov. 24-27, 2014
RK Singh	MDP on Emotional Intelligence for Personal and Work Excellence	NAARM, Hyderabad	Nov. 24-29, 2014
S Solomon, Amresh Chandra, TK Srivastava, SK Shukla, SN Singh, Swapna M, AK Sah	International Conference: IS 2014 on Green Technologies for Sustainable Growth of Sugar & Integrated Industries in Developing Countries	Nanning, PR China	Nov. 25-28, 2014

Name of the official	Name of the conference	Organised at	Date
Rakesh Kumar Singh	National Conference on Animal Nutrition Research Strategies for food Security	RAU, Bikaner	Nov. 28-30,
AD Pathak	Management Development Programme on Leadership Development	NAARM, Hyderabad	Dec. 1-12, 2014
Brahm Prakash	Annual Conference of Indian Society of Agricultural Marketing	SP University, Anand	Dec. 4-6, 2014
SK Shukla	FAI Golden Jubilee Seminar	New Delhi	Dec. 10-12, 2014
SR Singh	National Conference on "Emerging Challenge and Opportunities in Biotic and Abiotic Stress Management	DRR, Hyderabad	Dec. 13-14, 2014
AK Sharma, Brahm Prakash	74th Annual Conference of the Indian Society of Agricultural Economics	Dr. Babasaheb Ambedkar University, Aurangabad	Dec. 18-20, 2014
SI Anwar, LS Gangwar, Dilip Kumar	Silver Jubilee National Seminar on Present Scenario and Future Strategies for Processing and Value-addition of Agricultural Commodities	CIPHET, Ludhiana	Dec. 19-20, 2014
TK Srivastava, AK Singh	Reducing the Cost of Cane Cultivation vis-à-vis Sugar Production: A Growing Concern of Indian Sugar Industry	IISR Lucknow	Dec. 29, 2014
Amaresh Chandra	programme on Managing Technology Value Chains for Directors and Divisional Heads	Administrative Staff College of India, Hyderabad	Jan. 5-9, 2015
Dilip Kumar	XXX workshop of AICRP on PHT	UAS, Bangalore	Jan. 6-9, 2015
Ishwar Singh	2nd International Conference on Bio-resource and Stress Management	ANGRAU, Hyderabad	Jan. 7-10, 2015
Deeksha Joshi	International Workshop on Bridging Development Divide for Inclusive Growth through Science, Technology and Innovation	BBAU, Lucknow	January 16-17, 2015
Rakesh Kumar Singh	Animal Nutrition Association Conference -2015	AAU, Guwahati	Jan. 22-24, 2015
Amaresh Chandra, TK Srivastava, AK Sharma, AK Singh	12th Agricultural Science Congress on Sustainable Livelihood Security for Smallholder Farmers	NDRI, Karnal	Feb. 3-6, 2015
RD Singh	XXX workshop of AICRP on FIM	TNAU, Coimbatore	Feb. 4-6, 2015
AK Singh	Workshop on Improvement for Quality Training	Lucknow	Feb. 09-11, 2015
PK Singh	Eastern Zone Regional Agriculture Fair	CPRS, Patna	Feb. 19-21, 2015
RK Singh	National Conference of Indian Society of Extension Education	RVSKVV, Gwalior	Feb. 26-28, 2015
All the scientists	Technology and Machinery Demonstration Mela	IISR, Lucknow	Mar 20, 2015

18

Workshop/seminar/symposia organised

National Meet on Modernization of Jaggery Industry in India

National Meet on Modernization of Jaggery Industry in India was organized at IISR, Lucknow on November 1-2, 2014. More than 200 delegates from research & academic institutes, state departments and industries attended this meet. Modernization of jaggery industry was emphasized on aspects like development of suitable variety, modernization of process of location specific technological interventions and initiatives for timely transfer of technology. Shri Singh also highlighted the importance of agricultural research for the growth of Indian economy and advocated for adequate enhancement of the budget of ICAR for providing adequate research infrastructure and manpower to cater the needs of each and every farmer.

22nd Meeting of ICAR Regional Committee (Zone- IV)

Twenty second regional committee meeting of Zone IV was held during Sept. 5-6, 2014 at IISR, Lucknow. Shri Narendra Singh, Minister of Agriculture, Government of Bihar in his inaugural address said that UP and other states of this region have huge agricultural potential which need to be harnessed with effective synchronization of research and development departments. He exhorted the scientists and officials to pay maximum attention to the needs of the small farmers by improving the

Sh. Baidyanath Sahni, Minister of Animal and Fish Resources, Govt. of Bihar highlighted the need of developing diagnostic kits for detection of diseases among the cattle. Sh. P.K. Shahi, Minister of State for Environment and Forest, Govt. of Bihar informed about the various steps taken by the Govt of Bihar for sustainable agriculture.

In his Presidential address, Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR said that the region offers tremendous scope and opportunities for multifaceted growth of agriculture sector, including animal husbandry, fisheries, horticulture, sericulture and others. He said that agriculture needs a big push through technological interventions and technology transfer efforts, for which the ICAR is strongly committed.

He emphasized on multi -faceted growth in agriculture sector and exhorted the participants to utilize the multiple platforms to identify areas of regional importance in agriculture and deliberate over for setting priorities and develop road map for agricultural development in the states of Uttar Pradesh, Bihar and Jharkhand. Dr. Ayyappan welcomed the step of the Govt. for starting Rani Laxmibai University of Agriculture and Technology at Jhansi in Uttar Pradesh, and Indian Institute of Agricultural Biotechnology at Ranchi (Jharkhand).

Dr. S.K. Datta, Deputy Director General (Crop Sciences), ICAR welcomed the dignitaries and participants and highlighted the role of biotechnological interventions in crops and livestock for enhancing productivity in the region. Sh. V.N. Garg, Agriculture Production Commissioner, UP expressed his concern over declining average land holding of the farmers of this region and urged the scientists to develop high yielding varieties tolerant to the aberrant weather conditions.

Five publications, *viz*., Status of Centre State Coordination in Agricultural Research, Education and Extension published by IVRI, Bareilly; IISR Technorama and Farmers' Guide to Sugarcane Cultivation by IISR, Lucknow, Potential Agroforestry Systems for Jharkhand by NRC for Agroforestry and KVKs in accelerated growth of agriculture in Bihar and Jharkhand published by ICAR Zonal Project Directorate (Zone II), Kolkata were also released. During the inaugural ceremony of the meeting, 17 innovative and progressive farmers of the region were honoured with Recognition Award. The meeting was attended by over 150 delegates including functionaries of state agricultural universities, ICAR research institutes, senior officials of state line departments and progressive farmers from Uttar Pradesh, Bihar and Jharkhand.

IISR Foundation Day

The 64th Foundation Day of the Institute was celebrated at IISR, Lucknow on Feb. 16, 2015. Dr. Ravi Prakash Singh, Distinguished Scientist, Global Wheat Program, CIMMYT, Mexico was the Chief Guest who delivered the Foundation Day Lecture entitled "Sustaining wheat productivity and income growth through developing and deploying higher yielding, climate resilient, disease resistant and nutritious varieties". On this occasion, Dr. O.K. Sinha, Director of the Institute narrated the achievements made by the Institute during its journey since its establishment.

Hindi Pakhwara

Hindi Pakhwara was celebrated at the Institute during Sept. 14-30, 2014. Discussing the history of the development of Hindi language, Dr. S.R. Singh, Ex. Vice Chancellor, Rajasthan Agricutural University, Pusa (Bihar), Chief Guest urged the Scientists and Staff to do all of their work in Hindi. Dr. Singh 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. Congratulating all the staff members of the Institute for the prestigious *Indira Gandhi Rajbhasha Puraskar*, Dr. S. Solomon, Director of the Institute requested all to do the maximum work in Hindi. During the Hindi Pakhwara, several competitions like Evaluation of the articles for various sections received for publication in *Rajbhasha Patrika – Ikshu*, Review of the work done in Hindi during the year, Extension folder/ bulletin/leaflet on any technology developed by the Institute, Small documentary film about the Institute, Hindi typing in unicode, Presentation of Institute activities in 25 slides, Noting, Order writing, Extempore talk, Presentation of self-composed Hindi poem or *Ghazal*, *Antakchhari* and questionnaire based on general knowledge in Hindi were organized, in which staff of IISR participated. A shield entitled "*Mithas*" was presented to Dr. T.K. Srivastava, Head, Division of Crop Production for doing maximum work in Hindi.

A *Hindi Karyashala* was also organized during the *Hindi Pakhwara* which was participated by 49

personnel. During the Workshop, Sh. K.B. Dua, Senior Deputy Director General, NABARD; Dr. A.P. Roy, Geological Survey of India and Dr. S.P. Dixit, Ex. Professor, University of Lucknow delivered the lectured on various aspects of use of Hindi.

Four '*Rajbhasha Hindi Karyashala*' where organized by *Rajbhasha Prakoshtha* at IISR, Lucknow during 2014-15.

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

Institute was entrusted with the responsibility of Nagar Rajbhasha Karyanvayan Samiti (Karyalay-3), Lucknow by Department of Official Languages, Ministry of Home Affairs, Government of India with Director as the Chairman and Dr. P.K. Singh as Secretary. The Samiti includes 59 Government of India Offices situated at Lucknow as members. The first Six

monthly Review Meeting of newly constituted Nagar *Rajbhasha Karyanvayan Samiti* (*Karyalaya 3*) was organized at the Institute on Dec. 3, 2014.

Brain-storming discussion on "Reducing cost of cane cultivation *vis-à-vis* sugar production: A growing concern of Indian sugar industry"

One day brain-storming discussion on "Reducing cost of cane cultivation *vis-à-vis* sugar production: A growing concern of Indian sugar industry" was organized at the Institute under the aegis of NAAS, New Delhi on December 29, 2014.

World Photography Day

World Photography Day was celebrated at the Institute on Aug. 19, 2014. On this occasion, a photography competition was organized. The best photographs were also awarded. The photographs collected in the competition were displayed in a photography exhibition on the theme 'Monsoon Magic on Sugarcane".

First online examination of NET-2014

The ICAR first online examination of NET-2014 was successfully conducted at IISR, Lucknow during March 26 to April 4, 2014 along with 22 other centres across the country. Out of 1585 candidates allotted to IISR, Lucknow under 55 subject disciplines, 1211 candidates attended the examination which was

conducted in two slots of two hours every day.

ICAR's 19th All India Entrance Examination for UG & PG courses

The ICAR's 19th All India Entrance Examination for Undergraduate and Post Graduate courses was organized by the Institute at three centres at Lucknow on April 12 and April 13, 2014, respectively.

World Intellectual Property Day

The World Intellectual Property Day was celebrated on April 2, 2014 at the Institute. The scientists were apprised of the content of the free and weekly published online journal on patents, the official journal of Patents office. The photographs of technologies/equipment/products etc., were also captured to help in their better commercialization. The Institute officials also participated in one such program organized at Council of Science and Technology, U.P., Lucknow.

19

Distinguished Visitors

Name and designation of dignitary	Date of visit
Dr. Gurbachan Singh, Chairman, Agricultural Scientists Recruitment Board (ASRB), New Delhi	07.05.2014
Dr. A.N. Mukhopadhyay, Ex Vice Chancellor, AAU, Jorhat and Chairman RAC, IISR, Lucknow	29.05.2014
Shri D.N. Moghe, DDG, Doordarshan, Lucknow	04.06.2014
Shri Harish Chandra Joshi, Director, Hindi, ICAR, New Delhi	04.06.2014
Shri S.K. Pandey, DGM, HAL, Lucknow	04.06.2014
Shri S.S. Pattanshethi, IAS, Commissioner of Cane Development and Director of Sugar, Goverment of Karnataka	17.06.2014
Dr. S. Ayyappan, Secretary, DARE and D.G., ICAR, New Delhi	28.06.2014, 05.09.2014
Dr. Sanjeev Kumar Balyan, Hon'ble Minister of State for Agriculture and Food Processing Industries, Government of India	01.09.2014
Shri Narendra Singh, Minister of Agriculture, Government of Bihar	05.09.2014
Shri Baidyanath Sahani, Minister of Animal and Fish Resources, Government of Bihar	05.09.2014
Shri P.K. Shahi, Minister of State for Environ and Forest, Government of Bihar	05.09.2014
Dr. S.K. Dutta, Deputy Director General (Crop Sciences), ICAR, New Delhi	05.09.2014
Dr. C.S. Nautiyal, Director, CSIR-NBRI, Lucknow	09.09.2014
Prof. A.K. Tripathi, Director, CSIR-CIMAP, Lucknow	29.09.2014
Shri K.B. Dua, Sr. DGM, NABARD	29.09.2014
Dr. Bakshi Ram, Director, ICAR-Sugarcane Breeding Institute, Coimbatore	02.11.2014
Sh. Radha Mohan Singh, Hon'ble Minister of Agriculture, Government of India	08.11.2014
Ms. Nita Chowdhury, Secretary, Deptt. of Official Language, Ministry of Home Affairs, Government of India	20.11.2014
Dr. R. B. Singh, Assistant Director (Rajbhasha), Central Excise & Service Tax, Lucknow	03.12.2014
A seven-member delegation from Vietnam	29.12.2014
Dr. Ravi P. Singh, Distinguished Scientist, CIMMYT, Mexico	16.02.2015
Dr. Panjab Singh, Ex D.G., ICAR, New delhi	10.03.2015
Dr. R.P. Sharma, Ex Director, NRCPB, New Delhi	10.03.2015
Dr. U.S. Gautam, Zonal Project Director, Zonal Project Directorate, Kanpur	10.03.2015
Dr. J.S. Sandhu, Deputy Director General (Crop Sciences), ICAR, New Delhi	18.03.2015


धा मोहन सिंह
ीय कृषि मंत्री, भारत सरकार
क स्वागत एवं अभिनन्दन
नवम्बर 09, 2014
भारतीय गन्ना अनुसंधान संस्थान, लखनऊ


Dr. Sanjeev Kumar Balyan

20

Personnel

(As on March 31, 2015)

Director	:	Dr. O.K. Sinha
Crop Improvement		
Principal Scientist & Head	:	Dr. A.D. Pathak
Principal Scientist (Plant Breeding)	:	Dr. Raman Kapur
	:	Dr. Jyotsnendra Singh
	:	Dr. D.K. Pandey
	:	Dr. P.K. Singh
	:	Dr. Sanjeev Kumar
Principal Scientist (Genetics & Cytogenetics)	:	Dr. Sangeeta Srivastava
Principal Scientist (Genetics)	:	Dr. R.K. Singh
	:	Dr. M. Swapna
Senior Scientist (Agril. Biotechnology)	:	Dr. Sanjeev Kumar
Technical Officer	:	Mr. B.B. Joshi, Smt. Hem Lata Madhok, Mr. Raghvendra Kumar, Mr. Ram Kumar Gautam, Mr. Vimal Kumar Saxena, Mr. Ram Murty, Mr. Ram Sewak
Crop Production		
Principal Scientist & Head	:	Dr. T.K. Srivastava
Principal Scientist (Agronomy)	:	Dr. K.P. Singh
	:	Dr. S.N. 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 Officer(s)	:	Dr. R.K. Singh, Mr. Anil Kumar Singh, Mr. S.N. Srivastava
Crop Protection		
Principal Scientist & Head	:	Dr. Ram Ji Lal
Principal Scientist (Plant Pathology)	:	Dr. S.K. Duttamajumder
	:	Mrs. Sunita Lal
	:	Dr. Anil Kumar Singh
Principal Scientist (Agril. Entomology)	:	Dr. S.N. Sushil (on deputation)
	:	Dr. Maharam Singh
	:	Dr. Arun Baitha
Principal Scientist (Plant Pathology)	:	Dr. Dinesh Singh
Sr. Scientist (Plant Pathology)	:	Dr. Deeksha Joshi
Scientist (Plant Pathology)	:	Dr. Nithya K.
	:	Mr. S.K. Holkar
Technical Officer	:	Dr. D.C. Rajak (on deputation), Mr. Nar Singh, Smt. Pramila Lal, Mr. Amar Nath, Mr. B.L. Maurya, Mr. I.P. Maurya, Mr. M.P. Sharma, Mr. Shri Krishna Mishra

Agricultural Engineering

Principal Scientist & Head	:	Dr. A.K. Singh
Senior Scientist (Soil Water Cons. Engg.)	:	Dr. Rajendra Gupta
Senior Scientist (FMP)	:	Mr. Sukhbir Singh (on study leave)
Technical Officer	:	Mr. Jasbir Singh, Mr. Suresh Kumar Kushwaha, Mr. Chaman Singh, Mr. Julianus Minz, Mr. Rajendra Singh, Mr. Someshwar Mishra, Mr. Surya Dev Singh, Mr. Ram Sahay Vishwakarma

Jaggery Unit

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

Plant Physiology & Biochemistry

Principal Scientist & Head	:	Dr. Amresh Chandra
Principal Scientist (Plant Physiology)	:	Dr. A.K. Shrivastava
	:	Dr. R.K. Rai
	:	Dr. Radha Jain
Principal Scientist (Organic Chemistry)	:	Dr. Pushpa Singh
Technical Officers	:	Dr. Namita Arya, Mrs. Anita Sawnani (On study leave), Mrs. Meena Nigam, Mr. Ram Singh, Dr. Ram Kishor, Mr. Somendra Prasad Shukla, Mr. C.P. Prajapati, Mr. R.K. Singh

Economics & Statistics/AKMU

Principal Scientist & Incharge	:	Dr. P.K. Bajpai
Principal Scientist (Agril. Economics)	:	Dr. A.K. Sharma
	:	Dr. L.S. Gangwar
Senior Scientist (Computer Application)	:	Dr. S.S. Hasan
Technical Officer	:	Dr. Mani Ram Verma

Agrometeorology

Principal Scientist & Incharge	:	Dr. A.K. Shrivastava

Soil, Water, Plant Analysis and Microbiology Laboratory

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

Juice Lab

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

Extension & Training Unit

Principal Scientist & In-Charge	:	Dr. A.K. Sah
Technical Officer	:	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	:	Mr. Mahendra Singh, Dr. G.K. Singh, Sh. Devendra Singh, Mr. Adil Zubair

Farm Section

Principal Scientist & In-charge	:	Dr. T.K. Srivastava
Farm Managar	:	Mr. C.P. Singh

Technical Officer	:	Sh. Surendra Singh, Dr. Anoop Singh Sachan, Mr. B.B. Singh, Mr. Faujdar Singh, Sh. Vishwanath Ram
Institute Technology Management Unit		
Nodal Officer & Incharge	:	Dr. A.K. Sharma
Technical Officer	:	Mr. Brahm Prakash
Krishi Vigyan Kendra		
Principal Scientist (Horticulture) & Programme Coordinator	:	Dr. R.K. Singh
SMS (Animal Science)	:	Dr. Rakesh Kumar Singh
SMS (Home Science)	:	Dr. Veenika Singh
SMS (Plant Protection)	:	Dr. Deepak Rai
SMS (Agronomy)	:	Dr. Rakesh Kumar
Technical Officer	:	Mr. Ghanshyam Ram
Rajbhasha Prakoshtha		
Principal Scientist & In-charge	:	Dr. P.K. Singh
Technical Officer	:	Mr. Abhishek Kumar Singh
Art & Photography		
Principal Scientist & In-Charge	:	Dr. A.K. Sharma
Technical Officer	:	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. R.N.P. Bharti
In-Charge, Seed Production Unit	:	Dr. Sanjeev Kumar
In-Charge, Vehicle	:	Mr. Raj Kumar
In-Charge, Landscaping	:	Dr. Ram Ji Lal
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 Savant, Mr. Krishna Nand Singh, Mr. Lakhan Lal Verma, Mr. Umesh Kumar, Mr. Vishva Nath Mehrotra
IISR Regional Centre, Motipur (Bihar)		
Nodal Officer & In-charge	:	Dr. A.D. Pathak
Senior Scientist (Agronomy)	:	Dr. V.P. Jaiswal (on leave)
Technical Officer	:	Mr. G.K. Gupta
PME Cell		
Principal Scientist & In-charge	:	Dr. A.K. Sharma
Principal Scientist	:	Dr. S.K. Shukla
	:	Dr. M. Swapna
Technical Officer	:	Mr. Brahm Prakash, Mrs. Neelam Singh
Administration		
Senior Administrative Officer	:	Mr. Ratnesh Kumar
Finance & Account Officer	:	Mr. Raja Ram
Assistant Administrative Officer	:	Mr. K.P. Yadav

: Mr. R.K. Yadav
: Mr. Ram Das
: Mr. V.P. Tiwari

Security Officer : Mr. Sanjay Bhatnagar

Promotions

Name	Promoted to the post	Date
Dr. S.I. Anwar	Principal Scientist	18.09.2011
Dr. Rajesh Kumar Singh	Principal Scientist	22.07.2012
Dr. Ajay Kumar Sah	Principal Scientist	12.12.2012
Dr. M.R. Singh	Principal Scientist	17.12.2012
Dr. Arun Baitha	Principal Scientist	20.12.2012
Dr. Sanjeev Kumar	Principal Scientist	22.12.2012
Sh. Rajendra Gupta	Senior Scientist (P.B. 4 + RGP 9000)	17.12.2011
Dr. Sanjeev Kumar	Senior Scientist (P.B. 4 + RGP 9000)	05.11.2012
Dr. Dilip Kumar	Senior Scientist (P.B. 3 + RGP 8000)	01.11.2010
Dr. Diksha Joshi	Senior Scientist (P.B. 3 + RGP 8000)	28.06.2012
Smt. Hem Lata Madhok	ACTO	01.07.2007
Sh. S.K. Kushwaha	ACTO	01.01.2014
Sh. Adil Zubair	ACTO	01.01.2014
Sh. K.N. Singh	ACTO	25.04.2014
Smt. Hem Lata Madhok	Sr. Technical Officer	01.07.2002
Sh. Amar Nath katiyar	Sr. Technical Officer	01.01.2014
Sh. B.D. Singh	Sr. Technical Officer	01.01.2014
Sh. Abhishek Kumar Singh	Technical Officer	02.09.2012
Sh. Biswa Nath Ram	Technical Officer	23.03.2014
Sh. Srikishan	Sr. Technical Asstt	26.05.2014
Sh. Ajay Prakash	Technical	16.10.2014
Sh. Kapil Dev	Technical	16.10.2014
Sh. Maiku Kanojia	Technical	16.10.2014
Sh. Hans Raj	Technical	16.10.2014
Sh. Mool chand	Technical	16.10.2014
Smt. Manjo Srivastava	Technical	16.10.2014
Sh. Raja Ram	Technical	16.10.2014
Sh Madan Chand	Assistant	13.08.2014
Sh. Hari Lal	Assistant	13.08.2014
Sh. Awadhesh Kumar	Assistant	13.08.2014
Sh. Vishwa Nath Shukla	UDC	13.08.2014
Sh. Adya Prasad	UDC	13.08.2014
Sh. Sanjay Misra	UDC	30.08.2014
Sh. D.C. Pant	UDC	21.11.2014
Sh. Arjun	UDC, MACP	30.08.2014
Sh. Ramesh Prasad	UDC, MACP	30.08.2014
Sh. L.K. Ojha	SSS, MACP	16.02.2014
Sh. Radhey Lal	SSS, MACP	25.07.2014
Sh. Radhey Mohan	SSS, MACP	25.07.2014
Sh. Shatrughan	SSS, MACP	25.07.2014
Sh. Laloo	SSS, MACP	04.08.2014
Sh. Bhullan	SSS, MACP	30.08.2014

Joining

Name and designation	Transferred from	Date of joining
Dr. V.P. Singh, Principal Scientist	DWR. Jabalpur	08.12.2014
Dr. M.M. Roy, Principal Scientist	CAZARI Jodhpur	23.02.2015
Sh. Raja Ram, FAO	PDFMD, Mukteshwar	02.06.2014
Sh. Rakesh Kumar, SMS	New Appointment at Krishi Vgyan Kendra, IISR, Lucknow	24.12.2014
Shri Devendra Singh, Sr. Technical Officer	ICAR-Research Complex for NEH Region, Basar, Arunachal Pradesh	17.01.2015
Sanjay Gautam, T-4	IVRI Banaras	16.01.2015
Sh. Mahendra Pratap Tripathi, Driver	IIFSR, Meerut	02.03.2015

Transfer

Name and designation	Transferred to	Date
Ms. Visha Kumari V, Scientist	CRIDA , Hyderabad	06.05.2014

Superannuation

Name and designation	Date
Dr. S. Solomon, Director	31.12.2014
Dr. P.R. Singh, Principal Scientist & Head, Division of Agricultural Engineering	31.12.2014
Sh. Raman Banerjee, Senior Scientist	31.05.2014
Sh. Arun Kumar Srivastava, Principal Scientist	30.06.2014
Dr. Hema Pandey, Principal Scientist	31.10.2014
Dr. J.K.S. Gautam, CTO	31.12.2014
Sh. Ram Darash, ACTO	31.12.2014
Sh. V.K. Saxena, Sr. Technical Officer	31.03.2015
Sh. Kaloo Ram, Technical Officer	30.08.2014
Sh. Yogendra Roy, Sr. Technician	31.01.2015
Ms. Maya Agarwal, Assistant	31.07.2014
Sh. Ram Dutta, Assistant	31.01.2015
Sh. Ram Naresh Singh, Assistant	30.11.2014
Sh. Puran Lal, T-I-3	30.11.2014
Sh. Ram Awtar, SSS	31.07.2014
Sh. Gango, SSS	31.07.2014
Sh. Ram Prasad, SSS	31.10.2014
Sh. Sant Ram, SSS	31.01.2015
Sh. L.K. Ojha, SSS	28.02.2015

Notes

Notes

Drought contingency plan for sugarcane crop

Water management:

- In case of delayed onset of monsoon or prolonged dry spell during rainy season, it is advised to go for frequent light irrigations in place of heavy irrigation.
- Furrow irrigation with cut off at 85% furrow length should be adopted and flood irrigation need to be discarded to save the water and cover more crop area. Irrigating only alternate furrows would further enhance the irrigation efficiency and water saving.
- Dust mulching by shallow hoeing of inter –row spaces to break the capillaries would effectively prevent the moisture loss from deeper layers of the sugarcane fields.
- Sugarcane planting after wheat harvest, if delayed, till June should be entirely avoided.

Other measures:

- Lower dried leaves of standing sugarcane crop may be stripped and laid in the inter-row spaces as a mulch to conserve moisture and prevent weed growth.
- Earthing up on sugarcane rows should be done especially in autumn planted and autumn initiated ratoon crops to prevent wasteful tillering and also to effectively harvest water from likely rains.
- Spray of ethrel (12 ml in 100 litres of water) should be done on sugarcane leaves during the dry spell to mitigate the adverse effects of moisture stress.
- In order to maintain the crop growth and the resilience against dry weather, foliar spray of urea (2.5%) alone or in combination with MoP (2.5%) should be done.
- Control measures against sugarcane pests like top borer, black bug (ratoon), inter-node borer *etc*. need to be timely adopted.

Pyrilla management

Sugarcane leaf hopper is a serious sucking pest. Nymph and adults of this pest suck the sap mainly from lower surface of the leaves and excrete a sticky "honey dew" that falls on upper surface of the lower leaves. A black sooty mould (*Capnodium* sp.) gets developed on upper surface of the leaves and hinders photosynthesis reaction. Due to severe infestation of this pest leaves become yellow and finally plant gets died.

Control measures

Mechanical control: Removal and destruction of lower leaves containing maximum number of egg masses (egg masses are present on lower surface of old leaves in the form of white cotton swab) or remove lower 1-4 leaves from the crop and same may be used as green fodder.

Biological control: Collection and redistribution of its parasitoid, *Epiricania melanoleuca* @ 5,000 cocoons and 4-5 lakh/ha and conservation of predatory fauna (coccinellid beetles and spiders) by either avoiding broad spectrum insecticides or by using insecticides safer to bio-agents.

Chemical control: In the area where activity of bio-agents is nil then only insecticides may be used. Any of the insecticides given table may be used.

Nymph of Pyrilla on sugarcane leaf

Adults of Pyrilla

Insecticides that can be used for the management of *Pyrilla perpusilla*

Name of the insecticide	Quantity to be used per hactare	How to use
Contact Insecticides		
Acephate 75 WP	800-1000 g	Mix in 800 liters of water and do foliar spray with knapsack sprayer
Monocrotophos 36 SL	700-800 ml	-do-
Quinalphos 25 EC	400-500 ml	-do-
Fevalerate dust	20-25 kg	Dusting
Fumigant insecticide		
Dichlorovos 76 EC	400 ml	Mix in 800 liters of water and do foliar spray with knapsack sprayer
Systemic insecticides		
Imidacloprid 17.8 SL	400 ml	Mix in 800 liters of water and do foliar spray with knapsack sprayer
Dimethoate 40 EC	1.0 liter	-do-

Precautions:

- If one Cocoon of *Epiricania melanoleuca* per leaf or clump is present: **No insecticide**
- If coccinellid predators are plenty in number: **No insecticides**
- If one cocoon of *Epiriicania melanoleuca* per 90 cm distance present: **Use systemic insecticides**
- If pest population is heavy: **Fumigant/contact insecticide after one week of systemic insecticides should be applied**

भाकृअनुप–भारतीय गन्ना अनुसंधान संस्थान

लखनऊ–226 002, उत्तर प्रदेश, भारत

ICAR-Indian Institute of Sugarcane Research

Lucknow - 226 002, Uttar Pradesh, India

Tel: +91-522-2480726; Fax: +91-522-2480738

E-mail: iisrlko@sancharnet.in

www.iisr.nic.in