

RESEARCH ARTICLE

## CoLk 12209 (*Ikshu-7*): A new mid-late maturing sugarcane variety for north central and north east zone of sub-tropical India

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### Abstract

Sugarcane improvement programmes in India have concentrated on development of improved varieties suited to the different locations. Along with the early maturing sugarcane varieties, mid-late maturing varieties facilitate a proper varietal planning for efficient and extended functioning of sugar mills. ICAR-Indian Institute of Sugarcane Research, Lucknow has developed a mid-late maturing variety CoLk 12209 (*Ikshu-7*) for commercial cultivation in sugarcane growing states in the north central and north east zone. CoLk 12209 was tested in 6 locations in this zone along with three other test entries and was compared with the standard varieties viz., BO 91 and CoP 9301. The variety gave the best performance among all the genotypes tested, with an improvement of 15.5% and 16.28 % in CCS yield and cane yield respectively, over the standard variety BO 91. This variety exhibited 'Resistant' to 'Moderately Resistant' reactions against the major diseases and is 'Least Susceptible' to the major insect pests. *Ikshu-7* was identified for notification by the Varietal Release Committee of AICRP (Sugarcane) held at Bangalore during October 2018 and was notified for release in the zone, vide Gazette notification No. S.O.1498 (E) dated the 1st April 2019.

**Keywords:** CoLk 12209; Sucrose % in juice; CCS t/ha; Cane yield; Ratoonability; Multi-location testing

### Introduction

An effective exploitation of the variation in the existing gene pool forms the backbone of any crop improvement initiative. Sugarcane, a highly complex polyploid has been reported to have a high level of genetic variation inherent in the cultivated varieties, genetic stocks, species level clones and also the related genera (Aitken and McNeil 2010; Bakshi Ram and Hemaprabha 1992, 1998; Durai et al. 2015, 2020; Gill and Tripathi 1983; Govindaraj et al. 2014; Hemaprabha and Bakshi Ram 1997). Exploitation of this variation has resulted in several improved sugarcane varieties with high yield and sugar content, suited to the different sugarcane growing zones all over India

(Anonymous 2016). Even though there has been an improvement in the final sugar yield, mainly due to a betterment in the cane yield, a substantial improvement in the sugar content *per se* has not been achieved during the past few years, especially in the sub-tropical zone of India (even though the cultivation of improved varieties has led to an improvement in sugar yield and recovery in the recent years). Introgression of new genes/gene combinations and a general improvement in variability in the populations developed can go a long way in identifying high sugar genotypes with enhanced sugar accumulation potential. This can also result in the development of high sugar genetic stocks that can serve as good parental clones for

use in commercial hybridization programmes (Kapur and Swapna 2014; Kapur et al. 2015).

The north-central and north east zone, comprising of Bihar, eastern parts of Uttar Pradesh, Assam and West Bengal is an important sugarcane growing area, with states like Bihar having an illustrious past with respect to the sugarcane and sugar production (Pandey 2008). In the 1950s, Bihar with 33 sugar mills was a major sugar producing state in India. With the present-day situations demanding an improvement in the sugarcane yield and sugar recovery in this zone, concerted efforts are on for the development of improved varieties suited to this region that can also withstand the extreme climatic vagaries. ICAR-Indian Institute of Sugarcane Research, Regional Centre, Motipur, caters to this demand by developing varieties suitable to this particular zone.

The sugarcane improvement programme at ICAR-IISR, Lucknow has been taking care of the varietal breeding as well as the pre-breeding aspects for economically important traits. A long term pre-breeding programme for the development of high sugar genetic stocks was initiated during 1993. Intermating of the available high sugar varieties (and crossing with a few exotic sugarcane clones like Saipan-G) was carried out in the initial cycle and after evaluation in the seedling and clonal stages, high sugar genetic stocks were selected from the progenies. Each cycle of mating and selection was completed in 6-7 years. These high sugar genetic stocks were sent back to the National Hybridization Garden (NHG) at ICAR-Sugarcane Breeding Institute, Coimbatore to initiate the next cycle of crossing/intermating and selection and identification of a new set of high sugar genetic stocks. More than sixty high sugar genotypes have been included in the NHG for use as parental clones (Kapur et al. 2015; Swapna et al. 2019). Some of the improved clones with good yield and other desirable characters can be varietal

candidates for commercial cultivation. One such high sugar variety developed from this initiative, CoLk 94184, is under commercial cultivation in the north central and north east zone and has covered approximately 2.5 lakh hectares in the states of Bihar and eastern Uttar Pradesh (Indian Council of Agricultural Research 2020 ; Sugar industry and cane development department 2020)

Keeping in mind the demands of the sugar industry in the areas comprising of Bihar and eastern UP, the promising genotypes developed are evaluated at the regional centre of the Institute at Motipur also. The clones with good performance are notified for commercial cultivation in the north central and north-east zone. This paper discusses the development of a high sugar mid-late maturing sugarcane variety *Ikshu-7* from a bi-parental cross involving a high sugar genetic stock that was identified earlier in this programme.

## Materials and Methods

A long-term programme was initiated at ICAR-IISR, Lucknow in 1993 to develop high sugar sugarcane genetic stocks and this has resulted in a number of high sugar parental clones (Kapur et al. 2015, Swapna et al. 2020). These clones are being crossed among themselves or with other improved varieties depending on the flowering in these high sugar clones. Out of the several matings attempted during the crossing season 2004-05, the fluff from the bi-parental cross LG 95053 x CoPant 90223 sown in the glass house, gave rise to approximately 100 seedlings. LG 95053 is a high sugar genetic stock that was developed in the first cycle of mating and selection and has been registered as a high sugar sugarcane genetic stock (INGR 09054). The seedlings were transplanted to the field in 2005 and were evaluated based on the general vigour and hand refractometer brix readings. The clumps with a mean HR brix value of more than 18 (in October and/or in January)

were selected and advanced to first clonal (C-1) stage. Subsequent evaluation and selection in the different clonal stages resulted in the identification of a high sugar clone II-14-02. This had a mean HR brix value of 21.2 in the seedling stage during February and it recorded a mean sucrose % juice value of 17.6% at harvest (12 months) in the subsequent stages. The genotype was found to be moderately resistant to the prevalent races of red rot pathogen (*Colletotrichum falcatum*). This was evaluated in the station trials conducted at the Regional Centre, Motipur as LG 05447. Based on its excellent performance at Motipur, the genotype was proposed for inclusion in the multi-location testing in the All India Co-ordinated Research Project (Sugarcane), for the north central and north east zone as CoLk 12209, under the mid-late maturity group, in the Biennial Workshop of AICRP (Sugarcane) held in 2012.

The clone was evaluated at six locations along with the standard varieties BO 91 and CoP 9301. Simultaneously, testing for resistance against the prevalent races of the red rot pathogen, *Cf* 07 and *Cf* 08 (Mohanraj et al. 1997) and for the major insect pests was carried out. Agronomic trials also evaluated the overall performance under the recommended growing conditions. After an initial varietal trial, the Advanced Varietal Trial consisted of two plant crops and a ratoon crop involving four test entries viz., CoLk 09204, CoLk 12209, CoSe 12453, CoP 12438 and these were tested along with the two standard varieties BO 91 and CoP 9301. The experiments were laid in a Randomized Block Design with three replications. The plot size was 8 rows of 6 m each with an inter-row spacing of 90 cm. The recommended agronomic practices were followed as per the technical programme. The observations were recorded on cane yield and other yield attributes viz., number of millable canes (NMC), single cane weight (SCW), stalk length, stalk diameter and quality parameters like

Brix %, Sucrose% in juice, Purity %, CCS%, CCS t/ha, fibre content as per the programme. The data along with the disease and pest reactions and agronomic performance was used to identify the best performing varieties. Statistically analyzed data from the different locations was published in the Principal Investigator's Reports-Varietal Improvement Programme and was also presented during the 29<sup>th</sup> Biennial Workshop of AICRP (Sugarcane) in 2018. The variety was characterized on the basis of DUS Testing norms with 27 morphological characters (Singh et al. 2017). Molecular profiling of this best performing variety along with some standard varieties was done using four ISSR primer pairs, before proposing the variety for identification.

## Results and Discussion

The mid-late maturing test entry CoLk 12209 was tested at six locations in the north-central and north-east zone comprising of the eastern parts of Uttar Pradesh, Bihar, Jharkhand, West Bengal and Assam. Two plant crops and one ratoon crop were studied during 2016-2018, with three replications in each trial. The entries under testing were evaluated for cane yield and yield component traits, quality parameters like sugar and fibre content, ratoonability and reaction to major diseases and pests and also for their general agronomic performance (Anonymous 2017, 2018).

### *Cane yield and yield components*

The final cane yield and its component traits like NMC, SCW, stalk length and diameter were studied for all the entries tested, in comparison with the standard varieties BO 91 and CoP 9301 (Table 1). CoLk 12209 was superior to the other test entries and the standard varieties with a yield of 77.5 t/ha. This was an increase of 16.28 % and 10.16 % over the standards BO 91 and CoP 9301, respectively. The mean NMC was 110.22 ('000/

ha), compared to the standards BO 91 (107.06) and CoP 9301 (106.91). The mean SCW was 0.83 kg for CoLk 12209, which was superior to that in BO 91 by approximately 30 %. Stalk length, stalk diameter and other yield component traits were higher in the variety CoLk 12209 compared to the other test entries and standards (Anonymous 2017, 2018).

### Quality parameters

The mean sucrose content and fibre content in terms of sucrose % in juice, commercial cane sugar (CCS) yield, pol (%) in cane, etc., are important when considering the quality parameters in sugarcane. These traits were recorded at harvest stage (Table 1) for comparison among the test entries. *Ikshu-7* with a mean sucrose % juice value of 17.66 performed better than the other entries, with an increase of 5.56 % over that in BO 91. The mean CCS % was 12.10 and the mean sugar yield (CCS t/ha) from all the trials was 9.38 t/ha. This is an increase by 15.51 % over the mean sugar yield from BO 91 and by 9.71 % over that from CoP 9301. *Ikshu-7* was also superior to the qualifying varieties CoSe 12453 and CoP 12438 for mean CCS t/ha, by 3.53 % and 4.22 %, respectively. The mean fibre % was 13.12 in this variety whereas the values were 11.63 % and 12.26 %, for the standard varieties BO 91 and CoP 9301 respectively. The Pol in Cane value which takes into consideration

the fibre content also, was 14.33% in this variety.

### Performance of the ratoon crop

The assessment of ratoon performance of the test entries is an integral part of the varietal development programme. This evaluation caters to the preference of sugarcane growers for varieties with good ratoonability and good performance in the ratoon crop. The entries were evaluated for all the traits in the ratoon crop also. The variety CoLk 12209 exhibited better yield (mean value of 66.2 t/ha) over the standard varieties BO 91 (an increase of 12.17%) and CoP 9301 (an increase of 7.57%). The mean CCS yield was 7.8 t/ha in this test variety, with the values being 6.67 t/ha and 7.55 t/ha in BO 91 and CoP 9301 respectively. Thus the data indicated that the variety CoLk 12209 is a good ratooner with excellent performance in the ratoon crop (Anonymous 2017, 2018).

### Reaction to pests and diseases

The standard screening procedures were carried out in the field for artificial inoculation and screening for the most prevalent races of red rot pathogens *C. falcatum* (*Cf* 07 and *Cf* 08), for this particular zone. *Ikshu-7* recorded 'Resistant' (R) to 'Moderately Resistant' (MR) reaction to the cotton swab method and plug method of inoculations in most of the locations (Table 2). No natural incidence was reported in any of the

**Table 1.** Performance of CoLk 12209 for yield and quality attributes in zonal varietal trials\*

Variety	Cane yield (t/ha)	Sucrose %	CCS %	CCS yield (t/ha)	Pol % cane	Fibre %	Extraction %
CoLk 12209	77.50	17.66	12.10	9.38	14.33	13.12	60.30
<b>Standards</b>							
BO 91	66.65	16.73	11.56	8.12	13.97	11.63	56.82
CoP 9301	70.35	17.57	12.13	8.55	14.09	12.26	60.58

\*Mean value for the parameters averaged over the 6 locations for 2 plant crops and 1 ratoon crop

**Table 2.** Reaction of CoLk 12209 against red rot disease

Trial	Motipur		Buralikson	
	Plug	Cotton Swab	Plug	Cotton Swab
Advanced Variety Trial-I	MR/MR	MR/MR	R/MR	R/R
Advanced Variety Trial- II	MR/MR	Mr/MR	MR/MR	R/R

MR - Moderately Resistant; R - Resistant

**Table 3.** Reaction of CoLk 12209 against major insect pests

Trial	Pusa				Seorahi			
	TB	SB	ESB	RB	TB	SB	ESB	RB
Advanced Variety Trial-I	MS	LS	LS	LS	LS	LS	MS	LS
Advanced Variety Trial-II	LS	LS	MS	LS	LS	LS	LS	LS

TB – Top Borer; SB – Stalk Borer; ESB – Early Shoot Borer; RB – Root Borer; MS – Moderately Susceptible; LS – Least Susceptible

locations tested. The variety was MR to R to smut and wilt diseases in all the locations where the screening was done. ‘Least Susceptible’ (LS) to ‘Moderately Susceptible’ (MS) ratings were recorded for top borer and other borer complex in this variety (Table 3).

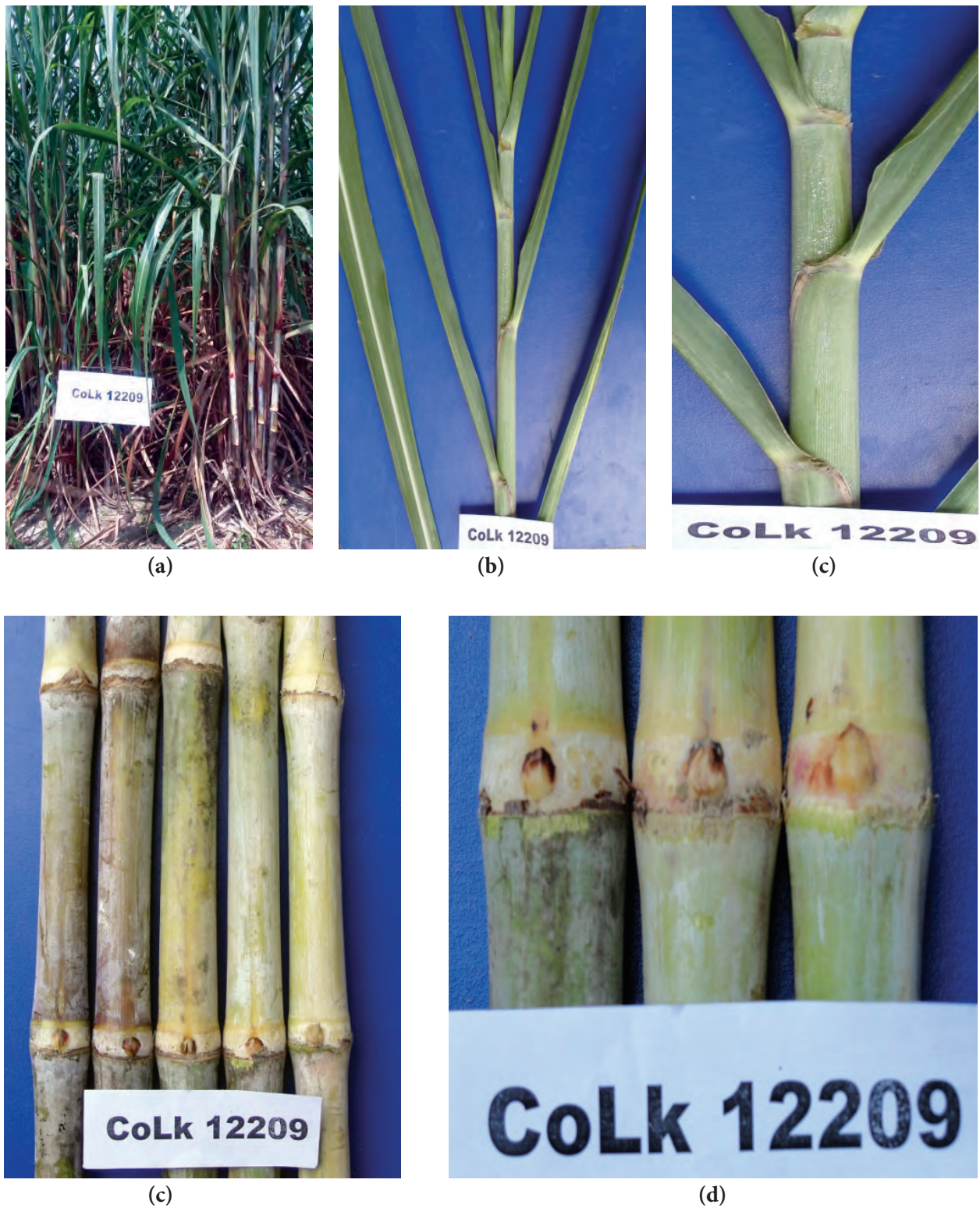
### ***Distinguishing characteristics and molecular profiling***

The important characteristics of this variety on the basis of DUS testing norms (Singh et al. 2017) are presented in Table 4. Some of the important morphological features are depicted in Fig.1. The molecular profiles were developed with four ISSR markers for this variety (Fig. 2) which gave distinct banding patterns for this test variety (Lane 10).

Considering all the above results, the variety CoLk 12209 (*Ikshu-7*) was concluded to be the best mid-late maturing variety suitable for north-central and north east zone, among all the entries tested. The variety was identified for notification by the Varietal Release Committee of the AICRP (Sugarcane) in the 32<sup>nd</sup> Biennial Workshop held in 2018. The National Active Germplasm at

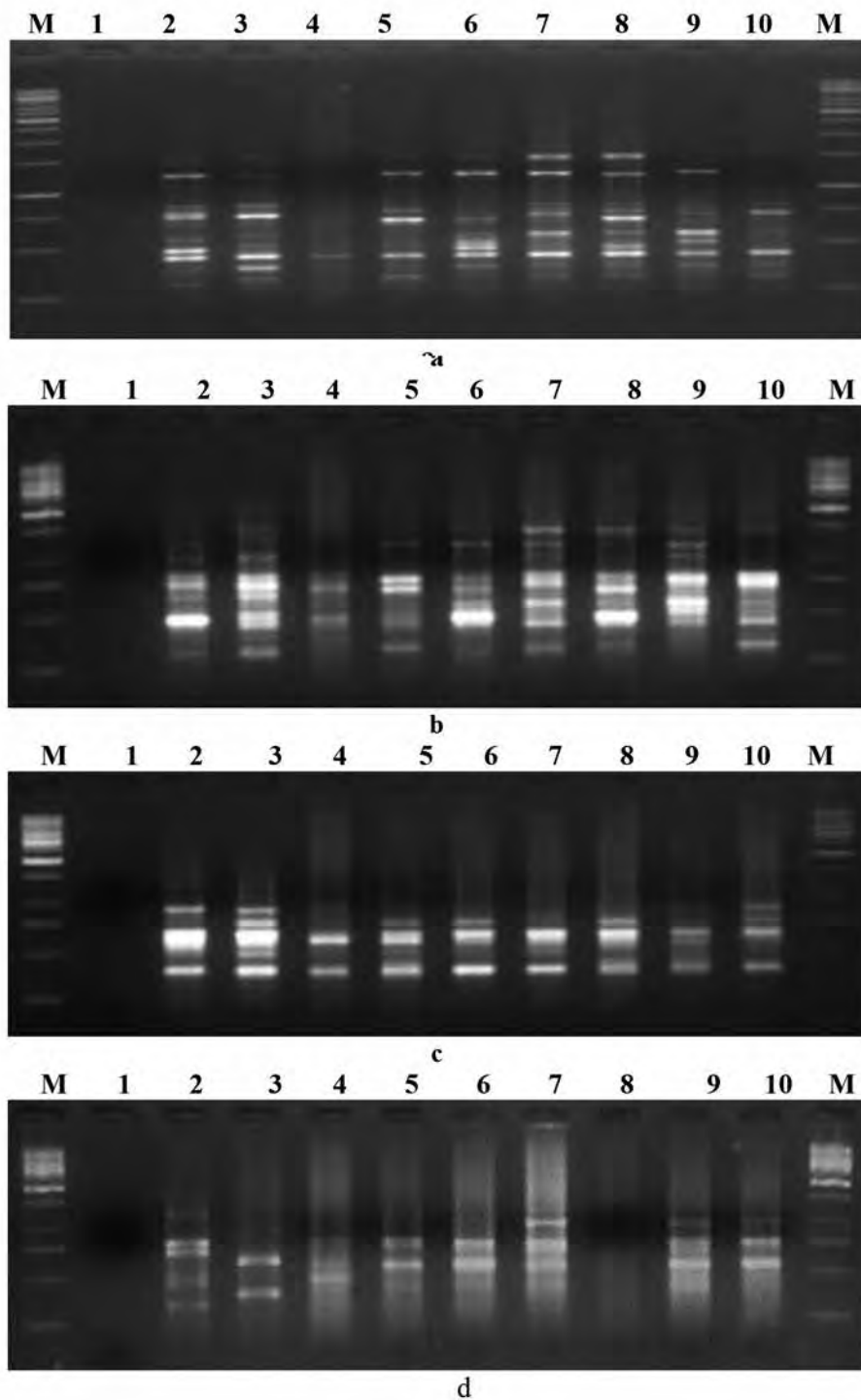
ICAR- Sugarcane Breeding Institute, Coimbatore assigned the index number SBI/2018/CoLk 12209/247. A National identity number, IC 628157 was allotted to the variety by ICAR-NBPGR, New Delhi. Subsequently, the variety was notified for release by the Central Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops, vide The Gazette of India notification SO 1498(E) dated the 01<sup>st</sup> April 2019.

Sugarcane breeding over the years has heavily relied on exploiting the variability present in the populations, along with other interventions (Nair 2014). A proper varietal planning with a right-mix of early and mid-late maturing varieties is an integral part of the sugarcane development programme for the sugar industry. The existing mid-late maturing varieties like BO 91 have been under cultivation in the north-central and north-east zone for quite a long time, dominating the sugar scenario in this zone. New and improved mid-late maturing varieties that can supplement/ substitute these existing varieties as and when the demand arises, are the need of the hour. This is also necessitated by the emergence of new races of pathogens as well as pests, along with other



**Figure 1.** CoLk 12209 : Field view and plant characters

(a) CoLk 12209 in the field; (b) & (c) : Top with leaf sheath and ligule; (d) & (e) : Internode and node with buds



**Figure 2.** Genetic fingerprint profiles of the nine sugarcane varieties as generated by the ISSR (inter simple sequence repeat) primers

(a) Primer UBC 826 ; (b) Primer UBC 834 ; (c) Primer UBC 840 ; (d) Primer UBC 847. Lanes: M: DNA size marker, 1: negative control, 2: Co 0238, 3: CoLk 94184, 4: CoLk 11203, 5: CoLk 11206, 6: CoLk 14201, 7: CoLk 14203, 8: CoLk 14204, 9: CoLk 12207, 10: CoLk 12209.

**Table 4.** DUS characteristics of sugarcane variety 'CoLk 12209' (*Ikshu-7*)

Sl. No.	Character	State
1.	Plant growth habit :	Erect
2.	Leaf Sheath: hairiness :	Absent
3.	Leaf Sheath: shape of ligule :	Crescent
4.	Leaf Sheath : shape of inner auricle :	Deltoid
5.	Leaf Sheath: Colour of dewlap :	Yellowish-green
6.	Leaf Blade: Curvature :	Curved-tip
7.	Leaf Blade: Width :	Medium
8.	Plant: Adherence of leaf sheath :	Semi clasping
9.	Internode: Colour (Not exposed to sun):	Green white (RHS 157 A)
10.	Internode Colour: (Exposed to sun):	Purple group (RHS N77C)
11.	Internode: Diameter:	Medium
12.	Internode: Shape:	Cylindrical
13.	Internode: Zig zag alignment:	Absent
14.	Internode: Growth crack (Split):	Absent
15.	Internode: Rind surface appearance:	Smooth
16.	Internode:	Waxiness: Light
17.	Node: Shape of bud:	Oval
18.	Node: Size of bud: (Measured from base of bud to the tip)	Small
19.	Node: Bud groove:	Absent
20.	Node: Bud cushion:	Present
21.	Node: bud tip in relation to growth ring:	Touching the growth ring
22.	Node: Prominence of growth ring:	Weak
23.	Node: Width of root band (opposite to bud):	Narrow
24.	Internode: Cross section:	Oval
25.	Internode: Pithiness:	Absent
26.	Plant: Number of millable canes (NMC): per stool	Medium
27.	Plant: Cane height:	Medium

stresses. The changing dynamics of occurrence of these stresses, especially due to the prevalent climate change also poses new challenges, demanding continued efforts in this direction. *Ikshu-7* is an ideal variety that meets all these demands of the sugarcane growers as well as

the sugar mills of this zone and will serve as a valuable addition to the varietal cafeteria in this sugarcane growing zone, giving a boost to the varietal planning in the sugar mill command area.

Chemical control against pests and diseases not being a preferred option in this crop, varieties



resistant/tolerant to the existing and emerging diseases and pests is the mainstay of stress management strategies for the crop, available to the sugar industry. Red rot an important disease in this crop, can lead to substantial economic losses, in the absence of an efficient management strategy (Viswanathan 2018). The intermittent breakdown of resistance/tolerance complicates the situation. CoLk 12209 with MR to R reaction and least susceptibility to the major diseases and pests is a suitable candidate to overcome this challenge. Also, the good performance of the variety in ratoon crop is an additional advantage with a large proportion of the sugarcane area in the country being occupied by ratoon crop. The DUS characterization through morphological traits and the molecular profiling of this improved variety are important steps against any infringement of plant variety protection rights. *Ikshu-7* is similar to the high sugar accumulating female parent LG 95053, for the many of the DUS traits recorded. The variety has very distinct characteristics compared to its reference varieties (as decided on the basis of DUS traits). The molecular profiling using ISSR marker system gave profiles that are different from some other varieties studied. Such distinct morphological traits and molecular profiles will also help in timely detection and avoidance of varietal mixtures in the farmers' field.

### Conclusion

The north central and north east zone, an important sugarcane growing area in the country faces several abiotic and biotic stresses and this necessitates improved location specific sugarcane varieties for the zone. The sugar industry in Bihar and other states of this zone is looking towards ways to revive itself, through application of innovative and sustainable technologies, the most important among them being the use of high yielding and high sugar varieties. The cultivation of improved high sugar varieties like *Ikshu-7*, along with

suitable innovative technological interventions can be an important step in this direction. This high sugar mid-late maturing variety CoLk 12209 (*Ikshu-7*) with its excellent performance in the plant and ratoon crops, will play a significant role in improving the productivity, profitability and sustainability of sugarcane cultivation in the zone.

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