SUGARCANE BREEDING PROGRAM OF NIA

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Sugarcane Improvement Methods

- Introduction
- Selection
- Hybridization
- Induced mutations
- Tissue culture

Handicaps in Conventional Breeding

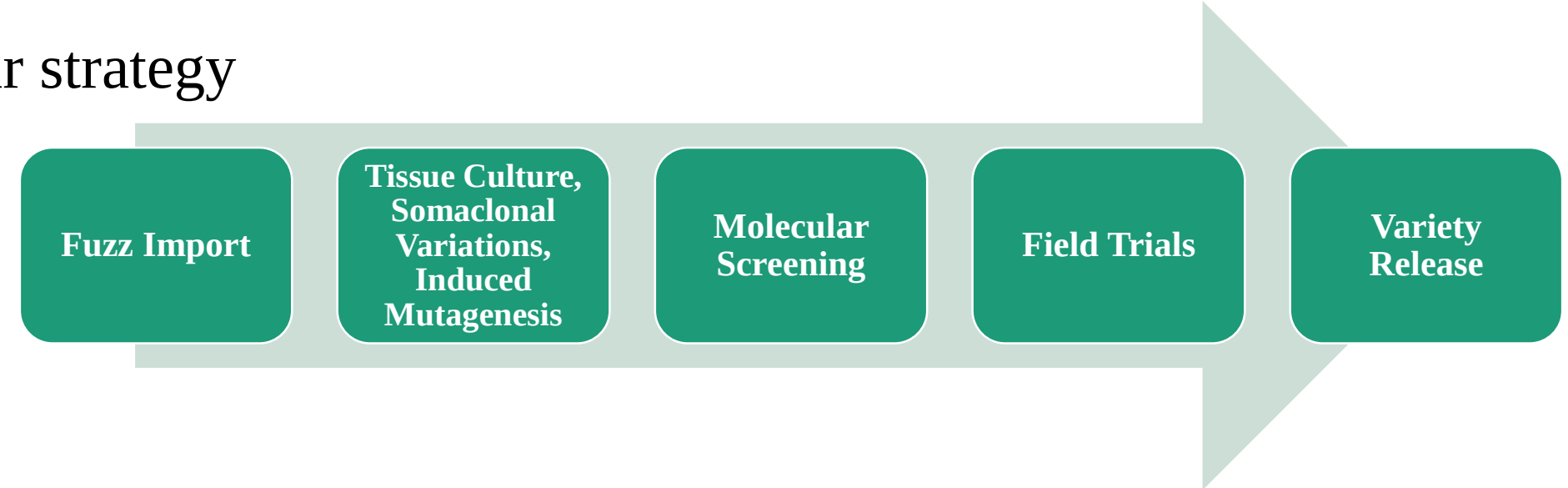
- Non flowering or sporadic flowering with poor seed setting under natural conditions
- If seed setting occurs, germination is very poor and mortality rate is very high
- Lack of facilities for induction of flowering by artificial means

Cane Yield, Sugar Recovery and Sugar Yield in main Sugarcane Growing Countries of the World

Country	Cane yield (t/ha)	Recovery (%)	Sugar yield (t/ha)
Australia	100.4	13.8	13.85
Egypt	110.8	11.5	12.74
Brazil	68.4	14.5	9.91
U.S.A.	80.2	11.7	9.38
Colombia	80.5	11.5	9.26
Mexico	79.5	11.6	9.22
India	66.9	9.9	6.62
Pakistan	50.3	9.2	4.63
World Avg.	64.4	10.6	6.82

Sugarcane Research Group, NIA

- Involved in sugarcane research through conventional and modern approaches
- Four varieties have been released already, upcoming lines ready for release
- Our strategy



Methods and Objectives

- **Methods**

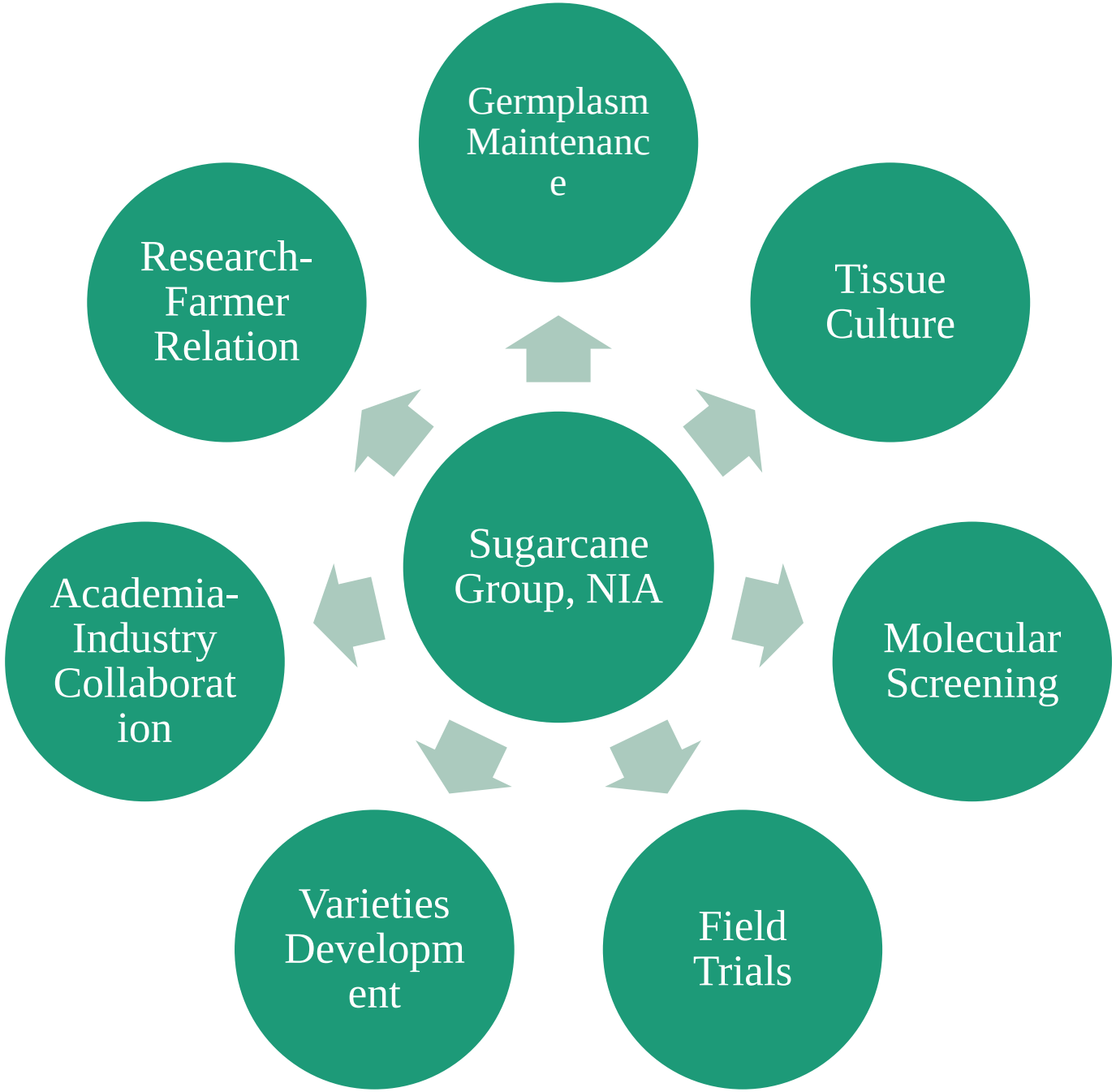
- Introduction
- Mutation Breeding
- Biotechnology

- ***In vitro* culture techniques**

- *a)* Callus culture
- *b)* Micropropagation
- *c) In vitro* mutagenesis

- **Objectives:**
- High cane yield
- High sugar content
- Early maturity
- Tolerance to biotic and abiotic stresses

Dimensions of Sugarcane Group, NIA



Germplasm

Germplasm	Cane yield (1500md/acre)	Cane yield (1000md/acre)	Sugar Recovery %
150 (exotic material)	NIL	12	38
Somaclones 400	8	10	8
Mutants 650	Will be evaluated in next generation		

- Fuzz

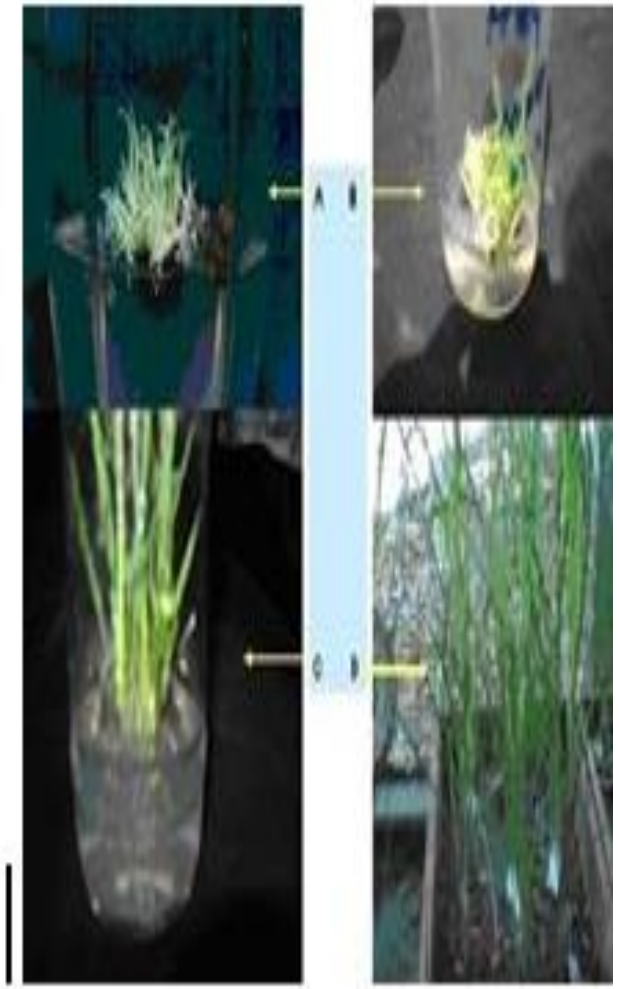
- Crosses obtained from Sri Lanka

In vitro Culture Studies in Sugarcane

Callus Culture

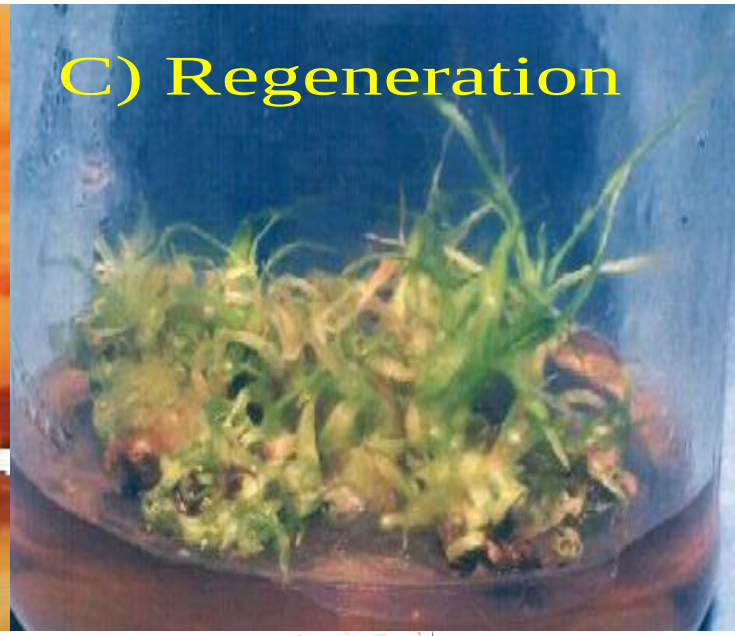
***In-vitro* Mutagenesis**

Micropropagation

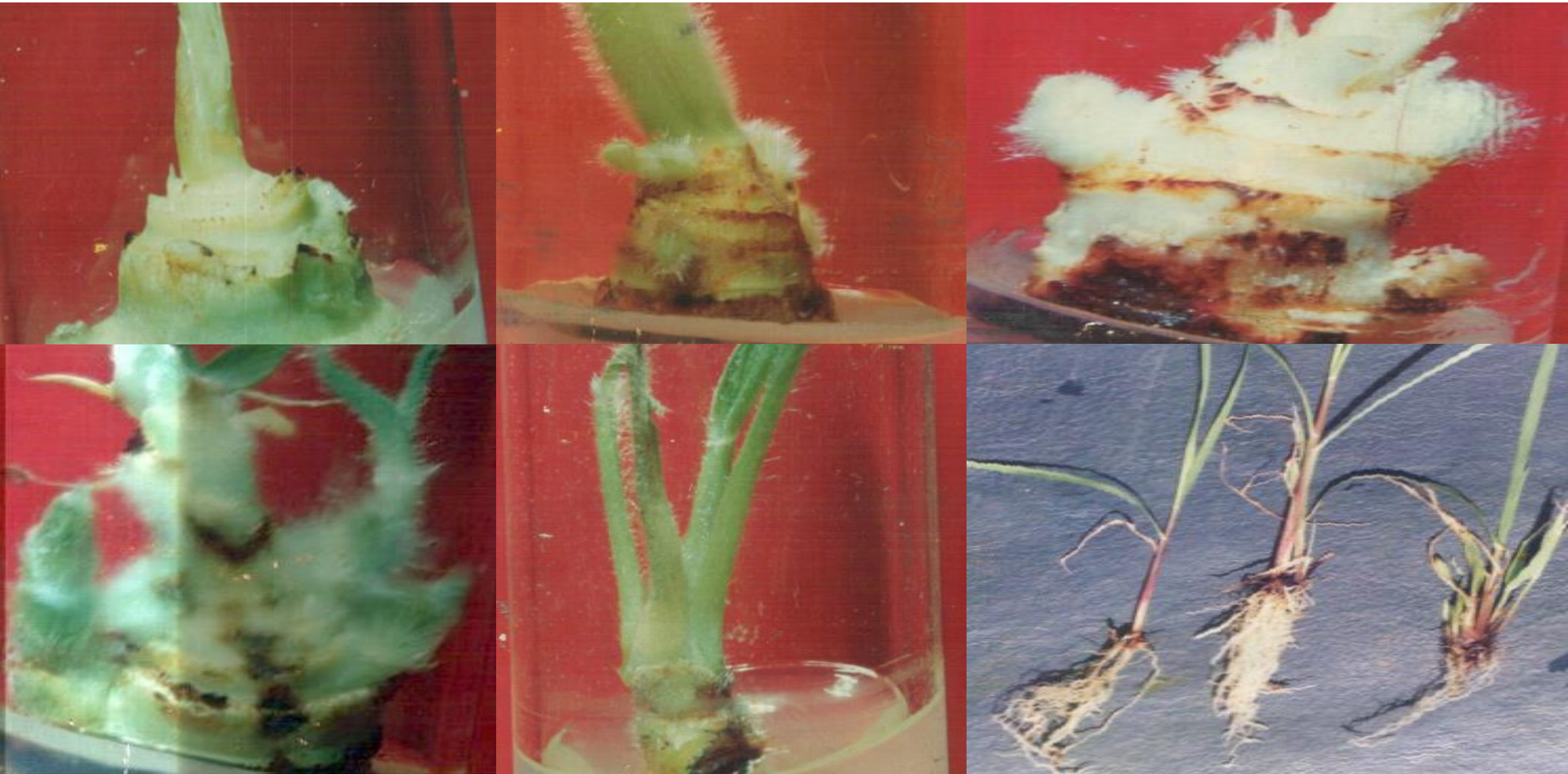


Direct Regeneration

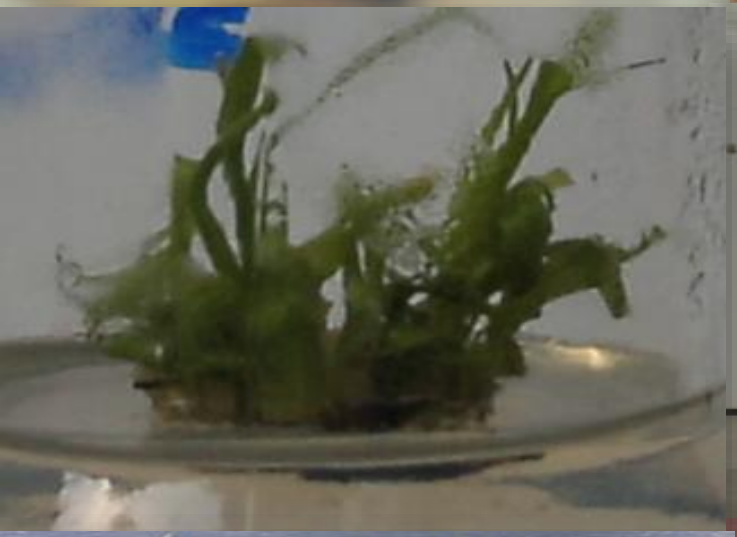
Callus Culture Studies



Micropropagation in Sugarcane

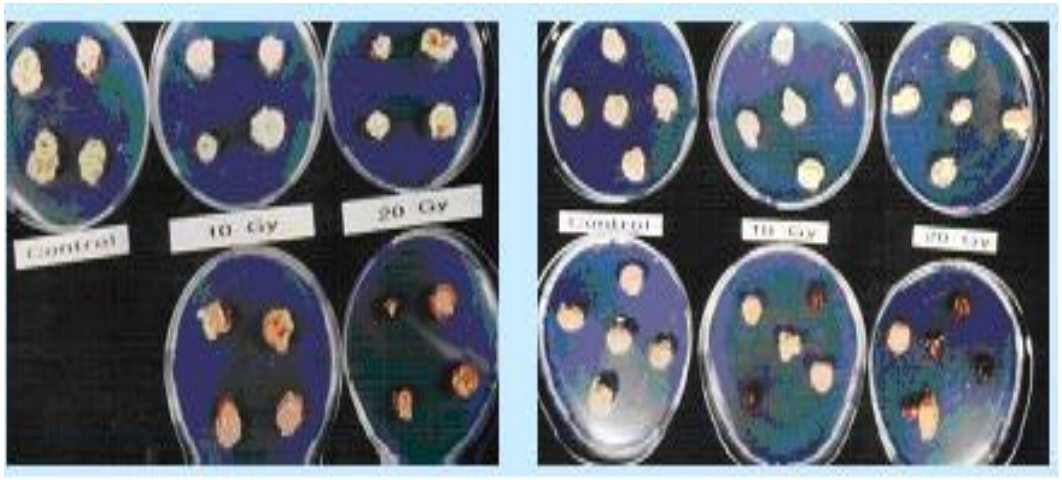




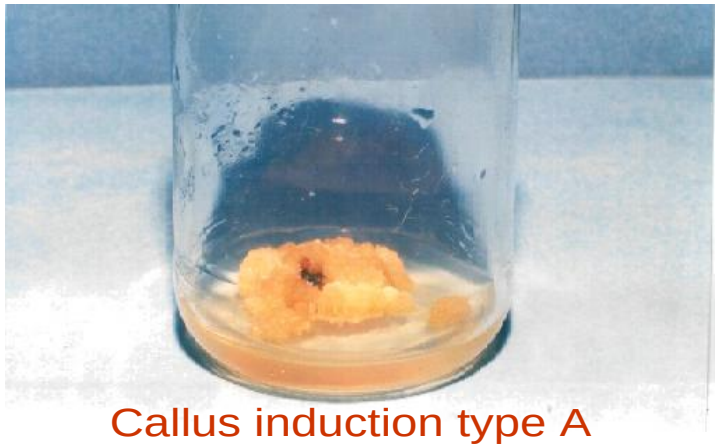





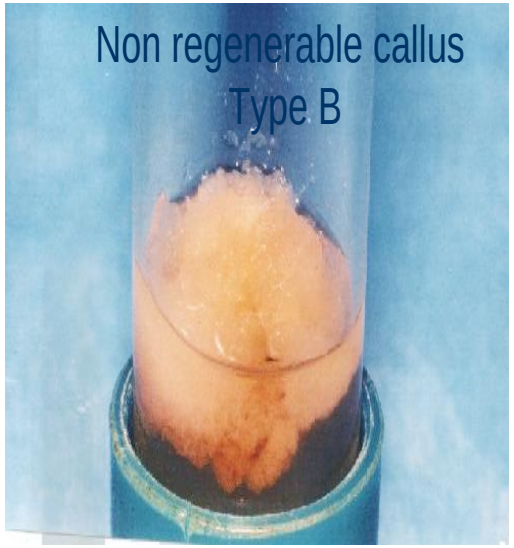

In vitro Mutagenesis Studies

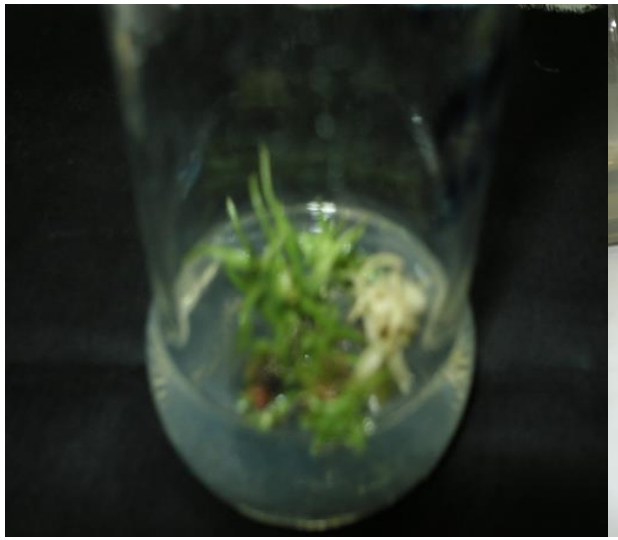


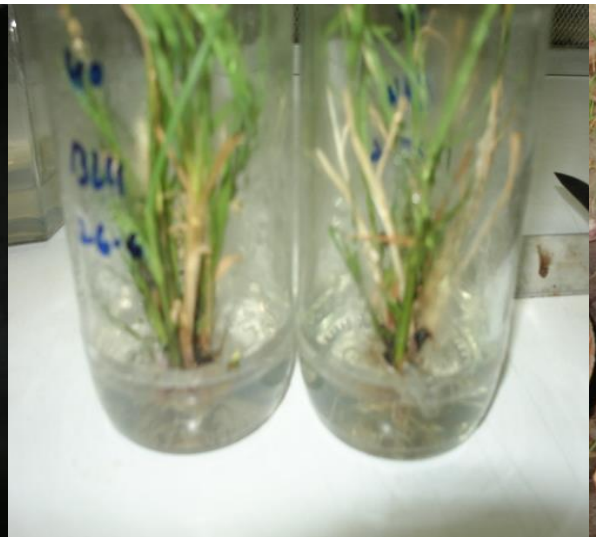
Explant of sugarcane



Callus induction type A







Variability Observed in the Mutants of NIA-98/P8

Characters	Parent (NIA-98)	Mutants (range)	% of Variation
Stalk/stool (no.)	5.11	4.50-8.97	-11.93 to 75.53
Cane length (cm)	325	240-290	-26.50 to -10.77
Cane thickness (cm)	2.60	2.33-2.63	-10.38 to 1.55
Cane weight (kg)	0.82	0.77-0.97	-6.09 to 18.29
Cane yield (t/ ha)	192.8	139.3-207	-27.75 to 7.36
CCS %	10.63	12.55-13.07	18.06 to 22.95
Fiber %	12.68	12.90-12.91	1.73 to 1.81
Sugar yield (t/ha)	20.50	17.76-27.08	-13.36 to 32.09

Variability Observed in the Somaclone of NIA96-792

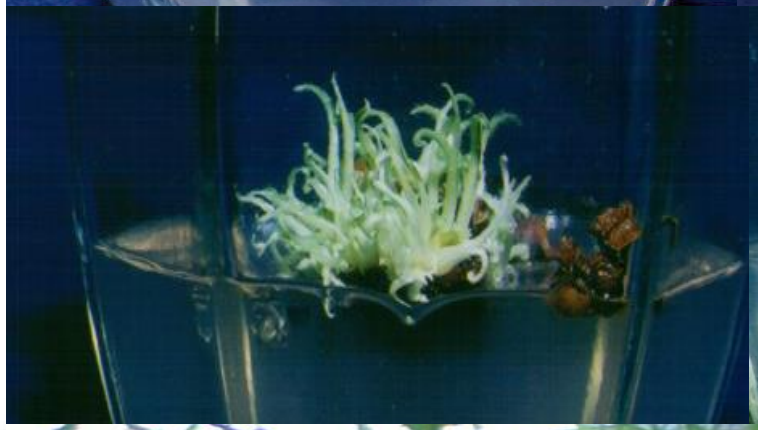
Characters	Parent (NIA-2004)	Mutants (range)	% of Variation
Stalk/stool (no.)	4.00	4.00-8.94	0 to 123.5
Cane length (cm)	201	254-316	26.36 to 57.21
Cane thickness (cm)	2.32	2.46-2.67	6.03 to 15.08
Cane weight (kg)	0.67	0.76-0.84	13.43 to 25.35
Cane yield (t/ ha)	120	135-202	12.5 to 68.33
CCS %	14.87	12.93-14.29	-13.04 to -3.90
Fiber %	11.32	11.29-12.81	-0.26 to 13.16
Sugar yield (t/ha)	17.84	17.52-28.86	-1.79 to 61.77

Variability Observed in the Somaclones of CP67-1026

Characters	Parent (BL4)	Mutants (range)	% of Variation
Stalk/stool (no.)	3.60	4.25-8.40	18.05 to 133.33
Cane length (cm)	290.0	185-318	-36.20 to 9.65
Cane thickness (cm)	3.20	3.10-3.33	-3.12 to 4.06
Cane weight (kg)	0.98	0.64-1.07	-34.69 to 9.18
Cane yield (t/ ha)	156.8	130-217	-17.09 to 38.39
CCS %	13.18	9.63-14.65	-26.93 to 11.15
Fiber %	12.58	12.43-13.87	-1.19 to 10.25
Sugar yield (t/ha)	20.67	12.55-31.84	-39.28 to 54.03

Direct Regeneration in Sugarcane



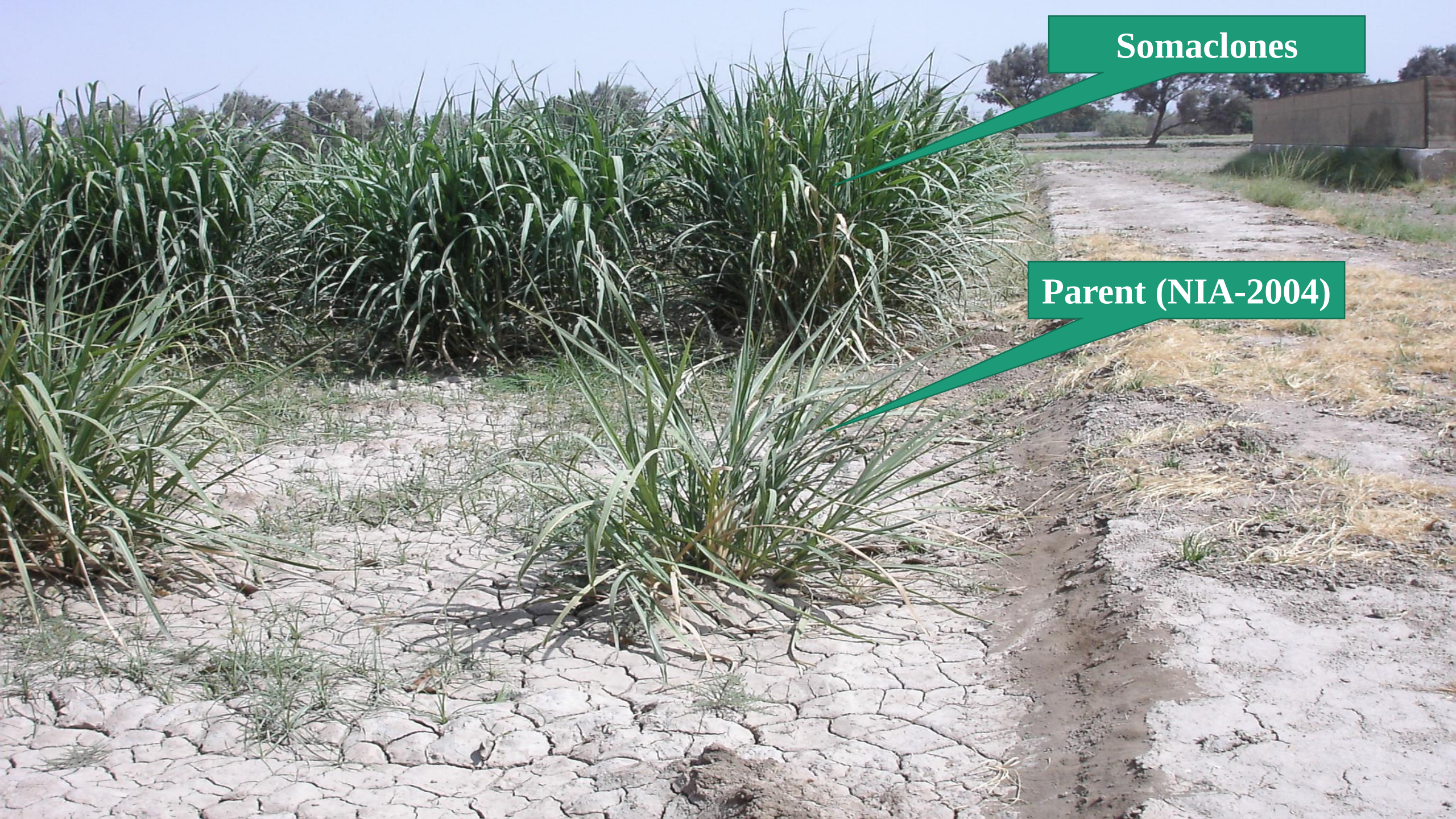

Parent of NIA92-912

Parent

Somaclones

In vitro Mutagenesis

Direct Regeneration


Somaclones
Parent (NIA-2004)

Variability Observed in the Direct Regenerants of NIA-2004

Characters	Parent (NIA-2004)	Variants (range)	% of Variation
Stalk/stool (no.)	4.00	4.00-9.00	0 to 125
Cane length (cm)	201	256-315	27.36 to 56.72
Cane thickness (cm)	2.32	2.35-2.58	1.29 to 11.20
Cane weight (kg)	0.67	0.65-0.83	-2.98 to 23.88
Cane yield (t/ ha)	120	129-200	7.50 to 66.66
CCS %	14.87	12.79-14.15	-13.98 to -4.84
Fiber %	11.32	11.19-12.68	-1.15 to 12.01
Sugar yield (t/ha)	17.84	16.59-28.33	-7.00 to 58.80

Variability Observed in the Direct Regenerants of BL-4

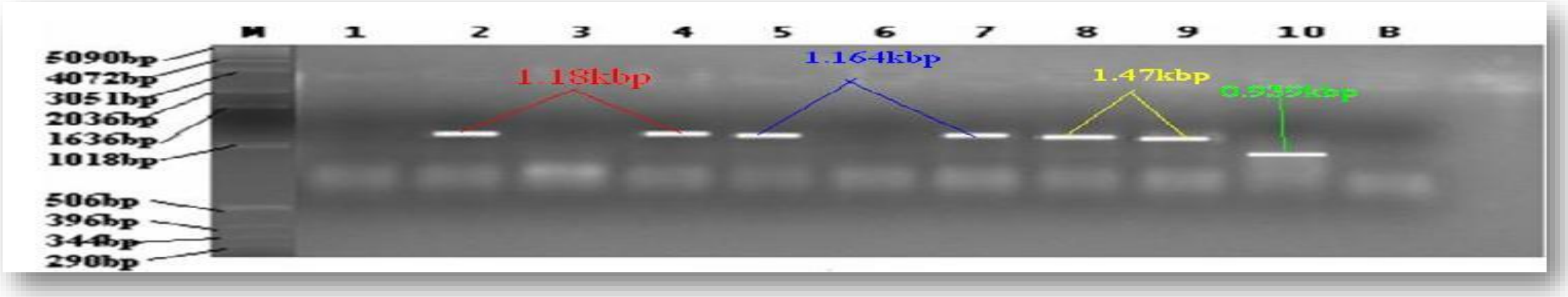
Characters	Parent (BL4)	Variants (range)	% of Variation
Stalk/stool (no.)	3.60	4.16-8.00	15.55 to 122.22
Cane length (cm)	290.0	175-313	-39.65 to 7.93
Cane thickness (cm)	3.20	2.93- 3.23	-8.43 to 0.93
Cane weight (kg)	0.98	0.74-1.05	-24.49 to 7.14
Cane yield (t/ ha)	156.8	138-216	-11.99 to 37.75
Sucrose %	17.17	12.62-19.05	-26.49 to 10.95
Fiber %	12.58	12.37-13.35	-1.67 to 6.12
Sugar yield (t/ha)	20.67	12.58-31.70	-39.14 to 53.36

Markers Assisted Selection (MAS)

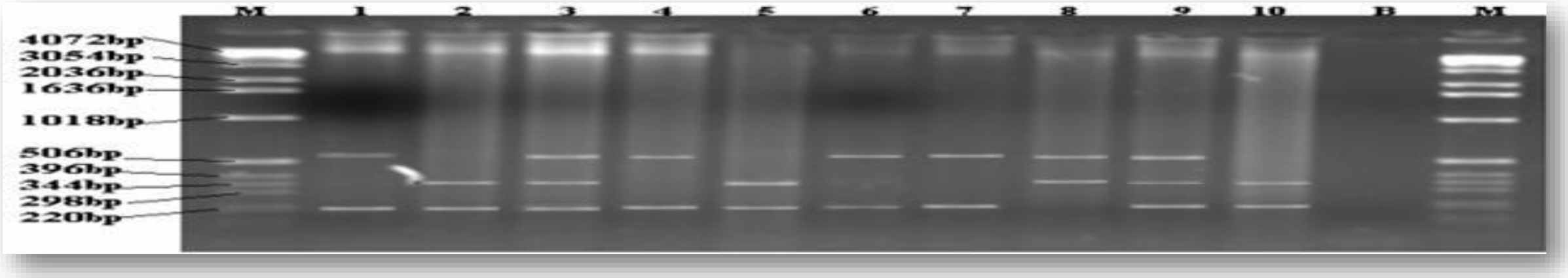
- Use of DNA markers that are tightly-linked to target loci as a substitute for or to assist phenotypic screening
- Different types-
  - AFLP, RFLP, RAPD, VNTR, SNPs,
    - EST-SSR
- Help direct selection on the genotype via markers or candidate genes

Markers Assisted Selection at NIA

- Molecular Markers Lab, NIA
- Screening of high yielding, and early maturing plantlets
- Rapid- screening at earlier stages
- Reliable- No environmental variations
- Economical- Selected field trials

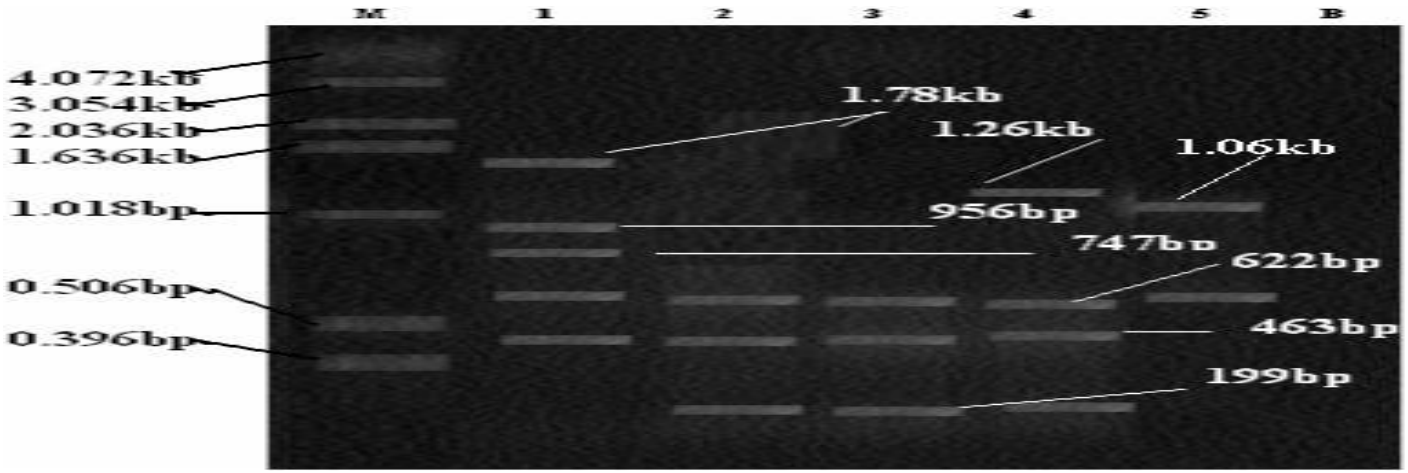


STS profile of sugarcane genotype using DREB sequence; M=DNA marker, 1= AEC82-1026, 2= GT-11, 3= AEC92-105, 4= AEC71-2011, 5= Thatta-10, 6= AEC82-223, 7= AEC81-0819, 8= NIA-2004, 9= AEC86-328, 10= L116, B= Blank



TRAP profile of sugarcane genotype using Sucrose Synthase; M=DNA marker, 1= AEC82-1026, 2= GT-11, 3= AEC92-105, 4= AEC71-2011, 5= Thatta-10, 6= AEC82-223, 7= AEC81-0819, 8= NIA-2004, 9= AEC86-328, 10= L116, B= Blank

Soluble Acid Invertase Enzyme Profile in Sugarcane



Zhu et al. (2000) reported that SAI which is classified as part of the SUC gene family (sucrose accumulation), was actually closer to the cold-tolerant gene CDPK.

Screening of Rust Susceptibility

Rust attack on CPF-234

No rust attack on NIA-2011

Performance of Promising Sugarcane Clones in Zonal Varietal Trial at NIA, Tando Jam

Clones	Cane length (cm)	Cane girth (cm)	No. of internodes	int. length (cm)	No. of tiller	Cane weight	Cane yield (tha^{-1})	Sugar yield
NIA-2010	277.89ab	2.35b	28.77a	13.50bc	6.45b	10.29a	102.92a	6.94a
NIA-2012	256.78abc	2.46b	20.44ab	15.72a	6.51b	7.59bc	75.88bc	5.23b
NIA-2011	309.44a	2.70a	26.55ab	14.66ab	6.32b	7.41c	74.17c	5.27b
Thatta-10	178.67d	2.71a	20.11b	11.28d	7.94a	6.02d	60.18d	4.92b
NIA-2004	222.22bcd	2.83a	24.44ab	12.61cd	6.68b	7.60bc	76.07bc	5.20b
NIA-2013	192.56cd	2.88a	20.66ab	12.50cd	6.59b	8.10b	81.00b	6.94a

Quality Parameters in November

Clones	TSS %	Fib er %	CCS%	Sugar Recovery	Sucrose %	Purity %	Sugar Yield
NIA-2010	18.15bc	16.38a	6.75b	6.34b	11.92 b	65.96 c	6.94a
NIA-2012	19.96 a	12.61bc	8.78a	8.25a	13.90a	69.59ab	5.23b
NIA-2011	17.79cd	13.63b	7.11b	6.68b	11.89 b	66.69bc	5.27b
Thatta-10	17.07 d	15.16a	6.48 b	6.09 b	11.24b	65.87c	4.92b
NIA-2004	18.29bc	13.82b	6.85b	6.44b	11.87b	64.97 c	5.20b
NIA-2013	18.97 b	12.15c	8.58a	8.06a	13.37a	70.44a	6.94a

Advance Yield Trial

Clones	Cane Length (cm)	Cane Girth (cm)	No. of Internodes	Int. length (cm)	No. of Tiller	Cane Weight	Cane Yield (tha^{-1})	Sugar Yield
Thatta-10	210.89a	2.65bc	19.99a	10.38a	6.66ab	10.33a	103.33b	6.38c
NIAS3	306.22a	2.62bc	23.89a	14.33a	7.66a	5.16c	51.67d	5.07d
CP78-2114	206.33a	2.63bc	19.44a	12.55a	6.33b	7.33b	73.33c	6.44c
CPSG-1632	266.00a	2.28c	21.11a	15.33a	6.66ab	7.66b	76.67c	7.30b
NIA-1254	270.78a	3.06ab	23.77a	12.33a	6.66ab	12.33b	123.33a	12.71a
BL4	211.89a	3.20a	20.55a	27.05a	6.33b	8.00b	80.00c	5.13d

Quality Parameters in November

Clones	TSS %	Fib %	CCS%	Sugar Recovery	Purity %	Sucrose %
Thatta-10	16.83c	13.50c	6.18c	5.81c	64.21c	10.81e
NIAS3	19.33b	14.23bc	9.80a	9.21a	76.01a	14.69b
CP78-2114	18.40b	12.46d	8.77b	8.24b	72.65ab	13.36c
CPSG-1632	21.60a	14.31b	9.55ab	8.97ab	70.69b	15.26ab
NIA-1254	21.30a	15.76a	10.31	9.69a	74.92a	15.95a
BL4	18.50b	15.50a	6.43c	6.05c	63.39c	11.72d

Station Yield Trial-I

Clones	No. of tiller	Cane weight	Cane yield (tha^{-1})	TSS %	Fib %	CCS%	Sugar Yield
NIA-207	7.33ab	10.33a	103.33a	18.20d	17.40a	8.25de	8.53a
1026P8	5.66c	5.16c	51.67c	18.86d	11.48h	8.92cd	4.59d
1026-P11	6.66abc	7.33b	73.33b	20.73bc	13.33e	9.32bc	6.83c
1026P24	7.66a	7.66b	76.67b	22.86a	13.97d	10.83a	8.32a
1026P12	6.33bc	7.33b	73.33b	21.80ab	12.90f	9.88b	7.22bc
NIA-87	6.00c	8.00b	80.00b	19.20cd	14.33c	10.03ab	8.02ab
1026P27	6.33bc	8.00b	80.00b	18.73d	12.33g	8.63cd	6.88c
Thatta-10	6.66abc	5.00c	50.00c	21.36ab	15.20b	7.70e	3.84d

Station Yield Trial-II

Clones	No. of tiller	Cane weight	Cane yield (tha^{-1})	TSS %	Fib %	CCS%	Sugar yield (t/ha)
L116 (Check)	6.66ab	5.00bcd	50.00bcd	21.37a	21.20a	7.70ef	3.84cd
NIA1026P3	6.33abc	5.66b	56.66b	18.23g	13.52h	6.20g	3.49de
CS-2453	7.00a	6.66a	66.66a	18.50fg	13.51h	7.90de	5.23a
CP-1491(Check)	5.00d	2.16h	21.66h	20.03cd	17.63b	6.91fg	1.48f
CP-1508	7.00a	3.50g	35.00g	21.40a	17.27c	10.03a	3.49de
CP-2402	6.33abc	5.66b	56.66b	18.13g	16.51d	7.84de	4.43bc
CS-2476	5.66bcd	5.16bc	51.66bc	20.46bc	13.04i	9.53abc	4.92ab
QSG20	7.00a	5.66b	56.66b	19.50de	17.13c	8.69cd	4.92ab
NIA1026-P2	6.66ab	4.16efg	41.66efg	21.20ab	14.92f	9.27abc	3.87cd
C-57	6.00abcd	4.00fg	40.00fg	18.50fg	10.80l	7.32ef	2.92e
1026-P23	6.33abc	4.33def	43.33def	19.23ef	12.05j	7.15ef	3.08e
CP-1401	6.66ab	4.83cde	48.33cde	18.43g	15.94e	7.04efg	3.39de
1026-P7	5.33cd	5.00bcd	50.00bcd	19.60de	14.52g	9.08bc	4.54abc
CS-2143	6.66ab	5.33bc	53.33bc	20.43bc	11.22k	9.59ab	5.15ab

NIA-2004

Average Yield 1600 Mnd/Acre

Potential Yield 2000 Mnd/Acre

Sugar Recovery in November 9%

Good Ratooner, Resistant to Whip Smut

Average Yield 1300 Mnd/Acre

Potential Yield 2400 Mnd/Acre

Sugar Recovery in November 8.5%

Good Ratooner, Resistant to Red Rot

NIA-2010 (First variety developed through tissue culture)

NIA-2011 (First variety developed through in vitro mutagenesis)

Average Yield 1400 Mnd/Acre

Potential Yield 1800 Mnd/Acre

Sugar Recovery in November 10%

Good Ratooner, Resistant to Red Rot

NIA-2012

Average Yield 1300 Mnd/Acre

Potential Yield 1700 Mnd/Acre

Sugar Recovery in November 10.5%

Good Ratooner, Resistant to Whip Smut, and Red Rot

NIA-2013

NIA-2014

UPCOMING LINES

To Enhance Molecular Screening Facilities in Sindh

To Capitalize, and Establish New International Collaborations

To Strengthen Industry-Research Relation

Future Plans

Thank You!