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Induced Mutations in Sugarcane—Effects of Physical and Chemical Mutagens on Commercial Cane Sugar and other Quality Traits*

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Co 1148, a wonder variety of sugarcane was subjected to various doses of physical (gamma-rays) and chemical (ethyl methane sulphonate and sodium azide) mutagens. Survived clones were inoculated with red-rot isolate of Co 1148 (most virulent). Mean, range and C.V.% were estimated for brix number, sucrose per cent, purity coefficient, commercial cane sugar, juice extraction per cent, fibre content in mutagenic populations of sugarcane, using healthy (HC) and red-rot infected clones (RRIC) at the time of red-rot rating and healthy clones (MHC) at the maturity of crop. In HC, RRIC and MHC, a significant increase in mean values, range and C.V.% was observed for most of the quality characters as compared to the control. Eight early maturing and high sugar mutants/clones were isolated.

Key Words: **Sugarcane, Mutagens, Brix number, Red-rot, Commercial cane sugar**

Introduction

The breeding potential of a crop species depends on the exploitation of the existing variability through selection or the variability generated through hybridization or mutation. In sugarcane, hybridization cum selection practice is a lengthy and cumbersome one. On the other hand, in a country like India with limited breeding programme greater emphasis might be given on mutation breeding especially if a serious disease or other pest were to threaten the industry. Co 1148, a wonder high-yielding variety, which occupied 70% of an area of sugarcane in north India bowed to red-rot (*Colletotrichum falcatum* Went.) in 1980. Variation in red-rot pathogen has been considered as the main cause of deterioration of this variety. Selection of useful clones after inducing mutations (Rao et al. 1966, Urata & Heinz 1971) for disease resistance and other characters without altering the yield potential have been reported. Several workers have attempted induction of mutations in this crop using either chemical or physical mutagens (Vijay

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Laxmi & Rao 1960, Jagathesan 1977, Jagathesan & Ratnam 1978, Balasundaram 1981, Hrishi et al. 1968 and Hrishi & Marimuthamal 1968). However, simultaneous study with two types of mutagens are very rare. In the present investigation, therefore, mutagenic effects of physical (gamma rays) and chemical (ethyl methane sulphonate and sodium azide) mutagens in separate treatments have been studied on commercial cane sugar and quality traits and compared with the variability generated by hybridization.

Materials and Methods

Single dormant bud setts of Co 1148 sugarcane variety were subjected to gamma irradiation at the Department of Genetics, Haryana Agricultural University, Hissar. Three doses of radiation of 2,4 and 6 Kiloröentgen (Kr) were applied. There were 100 bud setts under each radiation dose. Also, 100 bud setts were soaked in 1×10^{-3}M, 5×10^{-3}M and 1×10^{-2}M mutagenic solutions of EMS and SA. The crosses namely Co 1148 × unknown (general cross) and Co 1148 (susceptible) × Cos 767 (resistant) were attempted at Sugarcane Breeding Institute, Coimbatore (Tamilnadu), India. Fluffs of these crosses were received and sown on nursery beds. The soil mixture used in beds consisted of horse dung, silt and sand in the proportion of 3 : 3 : 1, respectively. The soil mixture was sterilized in an autoclave and filtered through a fine sieve to make it into fine tilth in the seed beds. Fluff was spread uniformly in a very fine thin layer so that there was one layer of fluff on the soil surface as far as possible. Beds were given water and covered with polythene sheets and made air tight. Irrigation was done daily by applying a shower of water from a sprinkler. The fluff germinated in seven days. Proper attention was paid during the early and subsequent growth of seedlings in the nursery beds.

Irradiated and chemically treated material along with control and seedling of each cross, were evaluated in randomized block design with three replications. Each treatment was grown in ten rows plot of five meter length with 90 cm spacing between rows and 50 cm spacing between setts/seedlings. Normal cultural practices were followed. Survival count was recorded after 60 days of planting. Out of 3600 total setts/seedlings planted, 2254 clones survived and matured in different treatments including crosses and control. Three or four canes in each of the survived clone were inoculated with red-rot isolate of Co 1148 (most virulent) in the second week of September by standard plug method (Chona 1954).

Commercial cane sugar and other quality traits were estimated individually and separately in twenty randomly selected healthy clones (HC) and red-rot inoculated clones (RRIC) at the time of red-rot rating and in healthy clones (MHC) at the maturity of the crop. Cane used in all the three cases i.e. HC, RRIC and MHC were from the same clone.

Results and Discussion

As sugarcane is a highly heterozygous polyploid and is normally clonally propagated, it presents peculiar difficulties and problems concerning techniques and interpretation of the nature of mutations induced. Whether, it is a gene mutation, or a somatic mutation or a mere phenocopy, should be decided with caution. While in other crop, mutation breeding is carried out with the aim of creating variability, breaking linkage between desirable and undesirable characters, affecting breakage of chromosomes and so on, in sugarcane the objective is to make improvement in any one of the important character like disease susceptibility or juice quality. In the present investigation mutagenic treatments

Table 1 *Mean values for six quality traits in healthy (HC) and red-rot infected clones (RRIC) at the time of red-rot*

		Kr-2	Kr-4	Kr-6	EMS 1×10^{-3}M	EMS 5×10^{-3}M	EMS 1×10^{-2}M
BRI Number	HC	15.91 ±0.29	15.69 ±0.18	15.36 ±0.23	15.60 ±0.22	15.12 ±0.30	15.64 ±0.26
	RRIC	12.66 ±0.47	13.03 ±0.44	11.90 ±0.41	12.34 ±0.44	11.97 ±0.42	12.57 ±0.45
	MHC	18.23 ±0.23	19.54 ±0.30	18.22 ±0.44	18.40 ±0.36	17.62 ±0.36	17.75 ±0.35
Sucrose, %	HC	12.04 ±0.24	11.88 ±0.17	11.83 ±0.16	12.02 ±0.20	11.56 ±0.26	12.23 ±0.25
	RRIC	8.75 ±0.41	8.75 ±0.36	8.11 ±0.36	8.48 ±0.47	8.64 ±0.36	8.84 ±0.34
	MHC	15.27 ±0.42	16.67 ±0.32	15.30 ±0.43	15.89 ±0.40	14.57 ±0.39	14.68 ±0.36
Purity coefficient	HC	75.74 ±0.55	75.64 ±0.55	77.09 ±0.54	76.85 ±0.82	76.41 ±0.60	78.17 ±0.57
	RRIC	68.57 ±1.02	66.65 ±0.90	67.10 ±1.71	69.46 ±1.13	71.50 ±2.18	69.20 ±1.63
	MHC	83.64 ±0.52	85.24 ±0.41	83.40 ±0.77	84.43 ±0.54	82.50 ±0.55	82.62 ±0.62
Commercial cane sugar	HC	7.72 ±0.17	7.63 ±0.13	7.61 ±0.11	7.79 ±0.15	7.45 ±0.19	7.93 ±0.18
	RRIC	5.28 ±0.29	5.18 ±0.24	4.81 ±0.25	5.27 ±0.28	5.39 ±0.30	5.36 ±0.22
	MHC	10.28 ±0.31	11.38 ±0.24	10.28 ±0.34	10.52 ±0.29	9.74 ±0.28	9.88 ±0.25
[Juice extraction, %	HC	61.86 ±1.28	59.99 ±1.20	60.11 ±1.23	62.02 ±0.89	60.36 ±0.71	60.90 ±1.14
	RRIC	58.37 ±1.65	53.67 ±1.88	54.17 ±1.65	58.46 ±1.58	56.81 ±1.77	58.85 ±1.62
	MHC	64.61 ±1.19	60.47 ±1.22	61.72 ±1.25	64.56 ±1.76	63.39 ±1.17	64.43 ±1.12
Fibre content	HC	12.69 ±0.71	13.29 ±0.40	13.27 ±0.41	12.64 ±0.30	12.31 ±0.23	12.95 ±0.36
	RRIC	13.91 ±0.55	15.00 ±0.30	15.05 ±0.39	13.86 ±0.51	14.41 ±0.59	13.70 ±0.52
	MHC	11.80 ±0.40	13.18 ±0.41	12.76 ±0.42	11.84 ±0.58	12.20 ±0.39	12.19 ±0.37

rating and in healthy clones (MHC) at the maturity of crop in mutagenic populations of sugarcane

SA 1×10^{-3}M	SA 5×10^{-3}M	SA 1×10^{-2}M	Co 1148GC	Co 1148× Cos 767	Co 1148× Control	GM	Range	CD at 5%
15.36 ±0.24	15.47 ±0.24	15.19 ±0.27	16.34 ±0.28	16.12 ±0.23	15.09 ±0.22	15.62	15.09–16.34	0.70
12.08 ±0.46	12.63 ±0.41	12.55 ±0.47	14.38 ±0.39	14.06 ±0.34	10.66 ±0.42	12.73	10.66–14.38	NS
17.68 ±0.25	17.87 ±0.34	17.88 ±0.36	19.00 ±0.35	18.65 ±0.35	18.51 ±0.30	18.28	17.62–19.54	0.94
12.17 ±0.21	11.19 ±0.19	11.62 ±0.25	13.19 ±0.26	12.80 ±0.19	11.90 ±0.20	12.10	11.90–13.19	0.86
8.45 ±0.38	8.56 ±0.39	8.33 ±0.38	11.15 ±0.31	11.20 ±0.28	8.04 ±0.35	9.01	8.04–11.20	2.06
14.64 ±0.28	14.82 ±0.39	14.91 ±0.42	15.93 ±0.36	15.68 ±0.37	15.56 ±0.30	15.30	14.57–16.67	1.06
79.31 ±0.69	77.15 ±0.51	76.70 ±0.63	80.72 ±0.33	79.44 ±0.29	75.70 ±0.53	77.41	75.64–80.72	NS
66.86 ±0.83	65.85 ±2.44	70.35 ±1.22	75.58 ±0.64	79.71 ±0.42	67.70 ±1.02	70.09	65.85–79.71	NS
82.70 ±0.57	82.82 ±0.64	83.23 ±0.80	83.78 ±0.53	83.99 ±0.89	85.04 ±0.43	83.53	82.50–85.24	NS
7.96 ±0.16	7.65 ±0.13	7.49 ±0.19	8.72 ±0.19	8.38 ±0.19	7.37 ±0.15	7.82	7.37–8.72	—
4.80 ±0.24	5.11 ±0.28	5.41 ±0.26	7.20 ±0.21	6.34 ±0.19	5.06 ±0.24	5.56	5.06–6.52	—
9.94 ±0.25	9.93 ±0.29	10.07 ±0.33	10.73 ±0.27	10.57 ±0.29	10.30 ±0.22	10.30	9.74–11.38	0.85
61.59 ±0.59	63.32 ±0.91	61.98 ±0.85	57.73 ±1.50	54.06 ±1.05	61.87 ±1.15	60.69	54.06–63.32	2.32
56.71 ±2.12	56.12 ±1.52	58.70 ±1.69	54.40 ±1.91	48.11 ±2.09	58.29 ±1.52	56.12	48.11–58.84	5.31
63.73 ±1.31	65.94 ±0.90	63.10 ±0.94	49.49 ±2.24	58.99 ±1.39	64.27 ±1.44	62.03	49.49–65.94	3.14
12.79 ±0.19	12.21 ±0.34	12.65 ±0.28	14.13 ±0.50	15.29 ±0.35	12.77 ±0.31	13.09	12.21–15.29	0.76
14.79 ±0.70	14.82 ±0.50	13.99 ±0.56	15.22 ±0.64	16.85 ±0.59	13.81 ±0.42	14.58	13.70–16.85	1.61
12.09 ±0.40	11.35 ±0.30	12.29 ±0.31	16.84 ±0.75	13.67 ±0.46	11.91 ±0.48	12.68	11.80–16.84	1.40

resulted in a dose-wise increase or decrease in a good number of quality characters.

Mean values along with their standard errors for six quality traits in various doses of mutagens are given in table 1. In HC, RRIC and MHC, a significant increase in mean values was observed for most of the quality characters as compared to the control. It indicates that mutagens proved effective in generating variability. It is also indicated by the spectrum of variation (table 2).

The relative magnitude of variation(C.V.%) is illustrated in figures 1a, b, c, d, e and f. The maximum variability for brix number at EMS 5×10^{-3}M SA 1×10^{-3}M and Kr 6, for sucrose per cent at EMS 5×10^{-3}M, EMS 1×10–M and Kr6, for purity coeffecient at SA 1×10^{-3}M, SA 5×10^{-3}M and Co 1148 × Cos 767, for commercial cane sugar at SA 1×10^{-2}M EMS 5×10^{-3} M and SA 1×10^{-2}M,

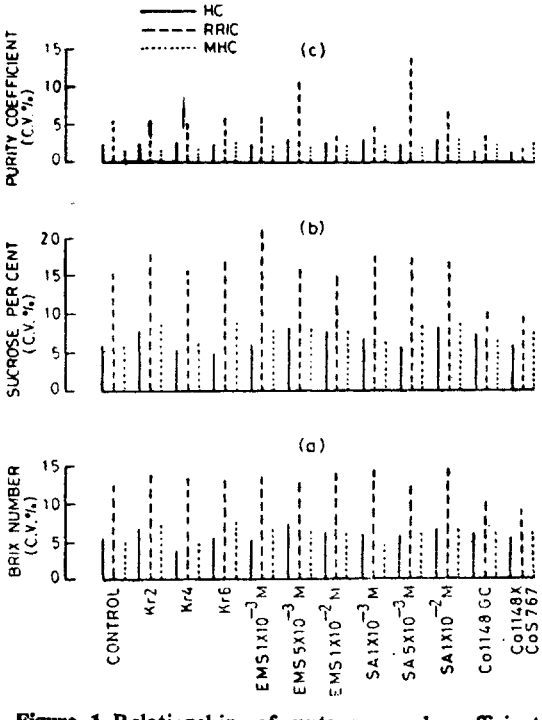

Figure 1 Relationship of mutagens and coefficient of variation

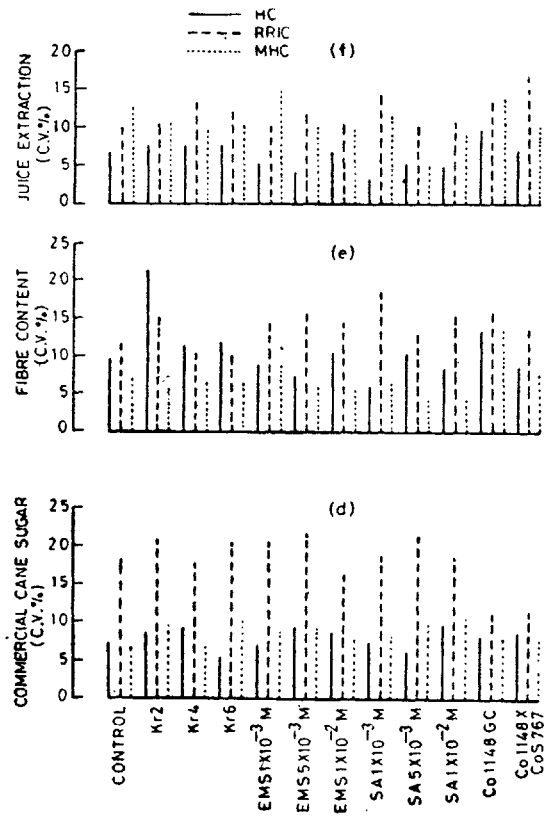

Table 3 *Identification of early maturing high sucrose mutants/clones in various mutagenic populations*

Clone/mutant	Sucrose per cent	Treatment
M2-72	14.66	EMS 1×10^{-3}M
M2-38	14.51	EMS 1×10^{-3}M
M2-23	13.89	EMS 1×10^{-3}M
M2-5	13.84	Kr4
M3-6	13.80	EMS 1×10^{-3}M
M2-10	13.70	Kr4
M2-28	13.70	Kr4
M3-10	13.70	Kr6
—	10.51	Control

Table 2 *Range for six quality traits in healthy (HC) and red-rot infected clones (RRIC) at the time of red-rot*

		Kr-2	Kr-4	Kr-6	EMS 1×10^{-3}M	EMS 5×10^{-3}M
Brix number	HC	12.91–17.80	13.91–16.71	12.97–17.37	12.20–17.09	12.16–17.17
	RRIC	7.40–17.17	9.36–15.87	7.45–14.80	6.00–15.69	6.45–15.49
	MHC	15.24–20.88	17.44–21.56	15.06–20,48	15.18–20.94	13.74–20.18
Sucrose, %	HC	8.66–14.47	9.38–13.84	9.34–13.70	8.94–13.89	8.41–13.62
	RRIC	4.24–11.50	4.54–11.79	4.26–11.11	3.55–12.63	3.82–11.90
	MHC	12.23–18.37	14.08–18.75	12.14–17.97	12.44–17.63	10.86–17.58
Purity coefficient	HC	64.25–83.27	64.20–84.81	66.60–82.81	65.77–85.24	62.08–82.60
	RRIC	53.27–81.95	53.73–77.14	49.81–78.22	46.22–78.94	43.22–90.00
	MHC	79.60–87.98	80.73–87.84	71.04–87.74	78.53–88.57	77.32–87.33
Commercial cane sugar	HC	5.20–9.59	5.47–9.24	5.76–9.11	5.57–9.38	4.94–8.99
	RRIC	2.06–7.32	2.17–7.55	2.06–7.03	1.69–8.23	1.91–7.64
	MHC	8.05–12.68	8.05–12.89	9.30–11.66	8.26–12.90	7.09–12.07
Juice extraction, %	HC	43.59–73.96	44.00–73.53	47.30–73.00	52.14–72.05	57.28–70.80
	RRIC	36.58–68.60	17.24–68.67	20.41–64.54	38.31–71.58	33.04–72.16
	MHC	57.14–80.43	48.00–75.00	53.12–72.72	42.10–74.14	52.27–70.83
Fibre content	HC	8.68–18.78	8.80–18.60	9.00–17.54	9.31–15.93	9.73–14.21
	RRIC	10.50–21.14	11.14–18.55	11.84–19.88	9.50–20.56	9.30–22.32
	MHC	6.52–14.28	8.38–17.83	9.03–15.62	8.62–19.30	9.72–15.91

for fibre content at Kr2, SA 1×10^{-3}M and EMS 1×10^{-3}M, for juice extraction per cent at Co 1148 GC, Co 1148 × Cos 767 and Co 1148 GC was observed in HC, RRIC and MHC respectively.

The overall picture of mean, range and coefficient of variation revealed that hybridization seems to offer a better scope for quality improvement but with a limitation of lengthy and laborious process. Therefore, chemical and physical mutagens appear promising for immediate utilization of variability. Some of the early maturing and high sugar mutants isolated from different mutagenic populations are given in table 3. Physical (Kr 4) and chemical (ethyl methane sulphonate) mutagens proved effective for quality improvement in sugarcane.

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rating and in healthy clones (MHC) at the maturity of crop in mutagenic populations of sugarcane

EMS 1×10^{-2}M	SA 1×10^{-2}M	SA 5×10^{-3}M	SA 1×10^{-3}M	Co 1148 (GC)	Co 1148 × Cos 767	Control
13.20–17.80	12.69–17.92	12.16–17.17	12.80–17.37	13.74–19.94	13.54–17.42	13.17–16.91
6.58–16.19	6.98–15.39	8.50–14.94	6.00–15.80	10.69–16.74	10.56–16.74	8.56–15.74
14.34–20.36	15.74–19.94	15.24–20.28	13.88–20.26	16.80–20.94	16.60–20.60	16.54–20.54
10.21–14.66	9.59–13.59	10.06–13.29	9.29–13.09	11.05–16.80	10.86–14.61	9.27–13.50
3.56–13.35	3.44–11.45	4.56–12.19	4.33–11.60	7.88–13.39	8.93–13.21	4.63–11.70
11.90–17.58	12.77–17.34	12.29–17.53	11.01–17.44	13.70–18.37	13.45–17.63	12.97–17.79
68.07–83.61	74.67–87.82	68.53–83.00	58.54–82.67	78.40–84.40	77.27–82.78	66.98–84.14
49.67–80.85	47.58–76.73	46.37–80.76	59.28–80.37	73.25–81.78	75.76–84.56	47.28–78.71
78.53–86.86	79.64–87.84	77.94–87.05	77.96–90.31	81.06–87.73	79.64–92.84	78.41–86.42
5.85-9.78	6.09–9.15	6.36–8.58	4.99–8.64	7.28–11.35	7.09–9.70	5.47–9.97
1.71–8.77	1.48–7.21	2.16–7.93	2.61–7.53	4.93–9.00	5.95–8.56	2.09–7.58
7.97–12.06	8.45–10.34	8.11–11.99	7.20–12.01	9.09–12.66	8.90–12.09	8.42–11.48
48.40–75.53	46.00–64.85	53.10–76.19	56.55–72.81	43.48–73.78	41.62–50.89	45.28–84.03
34.00–70.91	35.26–72.04	34.04–66.67	37.63–68.70	40.18–70.94	19.60–64.70	28.97–72.22
52.25–72.00	52.94–72.41	59.26–72.41	50.00–72.92	28.57–61.90	48.00–66.67	51.35–74.74
8.35–17.18	11.64–16.42	7.94–15.60	9.04–14.48	8.56–18.82	11.38–19.46	8.96–18.21
9.69–21.10	9.32–21.58	11.33–21.98	10.45–17.90	9.70–19.94	11.73–22.91	9.26–18.67
9.33–14.58	9.19–15.69	9.19–13.58	9.03–16.67	12.70–23.81	11.11–17.33	8.42–16.12

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