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Effects of Water-Logging on Juice Quality and Yield of Sugarcane

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Abstract: Chemical quality and yield performance were studied in six new sugarcane genotypes at normal and water-logging condition. The highest chemical indices, Brix % (22.20) and pol % (20.53) were found in January' 2002 in I-93/93 and I-110/93 respectively and the lowest in I-39/94 (Brix %: 14.93; pol %: 12.52) at water-logged cultivated cane in all months. The highest of purity % (95.79) and recovery % (13.05) were found in I-110/93 in the month December 2001 and January' 2002 respectively and the lowest in Isd 20 (purity % : 77.44; recovery % 6.49 in September 2001) at water-logged and normal cultivated cane respectively. The highest R.S. % (1.51) was found in I-39/94 in all months and the lowest in I-110/93 (0.09) at water-logged cultivated cane. Result showed that the highest tiller ($183.3 \times 1000 \text{ ha}^{-1}$ in I-110/93), millable cane ($117.8 \times 1000 \text{ ha}^{-1}$ in I-8/95), Yield (162.8 t ha^{-1} in I-8/95) and TSH ($16.63 \text{ ton sugar ha}^{-1}$ in I-110/93) were found in normal cultivated and the lowest were found in water-logged cultivated sugarcane (tiller $107.6 \times 1000 \text{ ha}^{-1}$ in Isd 20; millable cane $73.38 \times 1000 \text{ ha}^{-1}$ in Isd 30; yield 59.4 t ha^{-1} in Isd 20 and TSH $6.75 \text{ ton sugar ha}^{-1}$ in Isd 20). It is concluded that the highest percentage in juice quality were found in water-logged condition cultivated cane, on the other hand growth & yield performance were also found in highest in normal cultivated cane. In aspect of sugar production some tested cultivars showed (Isd-20, I-93/93 and I-8/95) similar performance in normal and water-logged cultivated sugarcane due to genetic potentiality and environmental adaptation on quality, yield and growth.

Key words: Water-logging, sugarcane, yield, purity, recovery, juice quality

Introduction

In Bangladesh sugarcane, a major cash-cum-industrial crop faces different vagaries of nature especially biotic/abiotic stresses during its life cycle. The growth and yield of a plant are modulated by a number factors of abiotic stress. The yield and quality effects due to water-logging depends upon the genotypes, environmental conditions, stage of development and the duration of stress (Orchard and Jessop, 1984; Choi *et al.*, 1986). In sugarcane cultivation, water logging is an acute problem particularly where surface drainage facilities are not adequate. Due to growing demand of vegetables and cereal crops one-third acreage of sugarcane is planted on relatively low land in Bangladesh where water remains stagnant for a longer period resulting in very poor yield. Higher water table during active growth phase adversely affects stalk weight and plant population leading to the reduction of yield of about one ton per acre for each one inch increase in excess water (Carter, 1976; Carter and Floyed, 1974). The effect of excess water stress using temporary or continuous flooding has been studied extensive (Scott *et al.*, 1989; Jackson *et al.*, 1978). The deleterious effects of water logging on crop growth and survival have been examined on other crops namely sunflower (Torres and Diedenhofen, 1981); wheat and barley (Pomeroy and Andrews, 1978).

Nutrient uptake is affected under water logging where

aerobic respiration by sugarcane root system is poor (Singh, 1990). Furthermore, under water logging condition, some morphological, anatomical, physiological and biochemical changes take place in plant for the sack of adaptation/survival (Barclay and Crawford, 1982). In general, all plants accumulate ethanol and malate, and increased levels of alcohol and dehydrogenase. However, no significant changes have been observed in report to pyruvate decarboxylase and malate dehydronase between aerated and flood stressed plants. The levels of sucrose, glucose and fructose however were found to higher during anerobic growth, but there was no correlation between sugar levels and flooding tolerance among different plants (Rahman *et al.*, 1985). Moreover, excess rainfall during late summer and monsoon quite often creates flooding problem and rears have no option but to use flood affected sugarcane. However, information is lacking on the effect of water. So, an effort has been made to comparative study to potential of genotypes leading to higher yield and Ton Sugar Per Hectare (TSH).

Materials and Methods

An investigation was conducted at the Bangladesh Sugarcane Research Institute (BSRI) farm during 2000-2001 cropping season. Six sugarcane genotypes Isd 20, Isd 30, I-93/93, I-110/93, I-39/94 and I-8/95 were planted in plots $6 \times 8 \text{ m}$ following Randomized Complete Block Design

(RCBD). The artificial water-logging was created for different periods ranging from 24 to 168 h, keeping 15 cm water level from the surface of soil in the field along with control. The water depth was maintained from grand growth phase to maturity. All recommended cultural practices were done as when required.

Laboratory analysis of cane juice was done at different maturity stages. The cane samples were crushed in a three-roller mill (power crusher) to get juice for analysis. Brix was determined by Brix hydrometer standardized at 20°C and Horne's dry lead method was used for sucrose determination using automatic polarimeter (ADP-220). The purity percentage of juice was calculated by ratio between sucrose content and corrected Brix reading. Purity and sugar recovery per cent were calculated from Brix and pol % as well as reducing sugars were determined by the method prescribed in Queensland Laboratory Manual (Anon, 1970). Data were recorded on different growth parameters viz. tiller number at 120 DAP (days after planting), number of millable cane, cane yield and sugar yield.

Data on different parameters were subjected to statistical analysis and mean values were compared using LSD at 5% level of significance (Gomez and Gomez, 1984).

Results and Discussion

The juice quality of sugarcane as indicated by Brix, Pol, Purity and Recovery per cent were significantly higher under water-logged condition than sugarcane grown in high lands free from water-logging in maximum cultivars of different months.

In the month of September 2001 the highest Brix per cent (21.43) was obtained in I-93/93 in water-logged sugarcane and the lowest was in I-39/94 (14.93) in normal cultivated sugarcane. In October, November, December 2001 and January' 2002 the highest Brix per cent was found in I-93/93 in water logged condition than normal condition. In December' 2001 cultivars I-39/94 produced lowest Brix per cent (16.57) in water-logged condition.

The highest Pol per cent was found in I-93/93 in water-logged condition of different months except December 2001 and January 2002. In December 2001 cultivars I-93/93 produced highest Pol per cent (17.99) in normal cultivated sugarcane. On the contrary, the lowest Pol per cent was found in Isd 20 in the month of September (11.70) and November (15.46) in normal condition. In January' 2002 the lowest Pol percent (15.68) was found in I-39/94 in normal cultivated sugarcane. I-110/93 produced lowest Pol per cent (14.03) in October and I- 8/85 produced lowest (16.42) in December 2001 in normal cultivated sugarcane. The highest Purity percent was found in the clone of I-110/93 in different months in water-logged condition.

The lowest purity percent was found in Isd 20 in the month of September, October and November 2001 in normal condition. In the month of December 2001 and January 2002 the lowest purity percent was found in I-39/94 in normal cultivated sugarcane.

In the month of September, October and November' 2001 cultivars I-93/93 showed highest recovery per cent in water-logged condition but in December' 2001 and January 2002, I-110/93 showed highest recovery per cent. On the other hand, the lowest recovery per cent was found in Isd 20 in normal cultivated in the month of September, October and November 2001. In the month of December' 2001 and January' 2002 cultivars I-8/95 and I-39/94 showed lowest recovery per cent respectively, in normal cultivated sugarcane. The water-logging decrease reducing sugars in maximum tested cultivars. In the month of January 2002, purity and recovery percentage were no significant difference between water-logged and normal cultivated cane.

We know that water-logged condition create red rot disease. Although the juice quality of sugarcane which indicated by Brix, Pol, Purity and Recovery per cent were significantly differ in water-logged condition than normal condition in maximum cultivars. Parthasarathy (1969) observed that the sugarcane crop is more susceptible to water-logging in the first 3 or 4 months it is somewhat tolerant and beyond that, hastens maturity. It has been reported elsewhere that physical and chemical properties of sugarcane are greatly affected with the change of maturity status (Dilley, 1970; Alexander, 1973). Dilley (1970) reported sharp physical and chemical changes during ripening as a result of catabolic and anabolic processes.

The growth parameters of sugarcane, which is estimated by, tiller, millable cane, cane yield and sugar yield were higher in different clones and varieties in normal cultivated sugarcane than water-logged sugarcane.

The highest tiller (183.3) was produced in I-110/93 in normal cultivated sugarcane. While the lowest in Isd 20 in water-logged sugarcane. Genotype I-8/95 produced highest millable cane (117.8) and highest yield (162.8) in normal cultivation practice while the lowest millable cane was found in Isd 30 (73.3), Isd 20 produced lowest cane yield (59.4) in water-logged sugarcane. The detrimental effects of water-logging on ton sugar per hectare, yield, millable cane and other parameters except chemical quality (Brix, pol, purity, recovery). Cultivars I- 110/93 showed the highest yield loss (33.97 t ha⁻¹) while I-93/93 showed the lowest (9.05 t ha⁻¹). On the other hand, Isd 30 showed the highest loss of ton sugar per hectare (TSH) (26.57 t ha⁻¹) and at the lowest loss was found in I-8/95 (4.04 t ha⁻¹) at water-logged cultivated cane. In water logged cultivated

Table 1: Brix per cent in juice of normal cultivated and water-logged sugarcane

Variety/Clone	Months									
	September 2001		October 2001		November 2001		December 2001		January 2002	
	N	WL	N	WL	N	WL	N	WL	N	WL
Isd 20	15.13g	19.10d	17.37f	20.40d	18.20fg	19.80d	20.17abcd	19.70cd	20.37cd	20.33cd
Isd 30	18.10e	20.23bc	18.93e	21.27bc	19.00e	20.70ab	19.10de	20.97a	20.93bc	21.60ab
I-93/93	19.53cd	21.43a	18.80e	22.13a	19.90cd	21.17a	21.10a	20.77abc	21.40ab	22.20a
I-110/93	16.50f	19.90bc	16.33g	20.70cd	18.63ef	20.40bc	19.80bcd	20.80ab	19.57d	21.43ab
I-39/94	14.93g	17.70e	16.60g	19.40e	18.90e	18.03g	19.33de	16.57f	18.37e	20.27cd
I-8/95	17.73e	20.37b	17.33f	21.50ab	17.83g	21.07a	18.33e	20.63abc	18.57e	20.70bc
LSD (5%)		0.74		0.73		0.51		1.08		0.92
LSD (1%)		1.00		0.99		0.69		1.47		NS
SEm (±)		0.23		0.25		0.18		0.37		0.32

Table 2: Pol per cent in juice of normal cultivated and water-logged sugarcane

Variety/Clone	Months									
	September 2001		October 2001		November 2001		December 2001		January 2002	
	N	WL	N	WL	N	WL	N	WL	N	WL
Isd 20	11.70g	16.65d	14.25f	18.04c	15.46f	17.62bc	17.94cde	18.03cde	17.97d	19.10c
Isd 30	16.10de	18.34bc	16.56d	19.85ab	17.17cd	18.73a	17.64de	19.48ab	18.78cd	20.29ab
I-93/93	17.73c	19.74a	16.88d	20.28a	17.86b	19.20a	17.99cde	18.98abc	19.46bc	20.42ab
I-110/93	14.25f	18.58bc	14.03f	19.36b	16.82de	18.61a	18.47bcd	19.93a	18.06d	20.53a
I-39/94	12.52g	15.42e	14.50f	17.03d	16.46e	15.60f	17.04ef	14.18g	15.68f	18.58cd
I-8/95	15.63e	19.05ab	15.16e	20.06a	15.52f	18.88a	16.42f	19.13abc	16.72e	18.84cd
LSD (5%)		0.86		0.65		0.67		1.21		0.97
LSD (1%)		1.16		0.88		0.90		1.65		NS
SEm (±)		0.27		0.22		0.24		0.44		0.33

N = Normal Cultivated Sugarcane; WL = Water-logged Sugarcane; Different letter indicates significance difference as per LSD at 5% level; NS = Not Significant

Table 3: Purity per cent in juice of normal cultivated and water-logged sugarcane

Variety/Clone	Months									
	September 2001		October 2001		November 2001		December 2001		January 2002	
	N	WL	N	WL	N	WL	N	WL	N	WL
Isd 20	77.44g	87.17de	82.31e	88.48cd	84.96d	89.56b	88.95d	91.53c	88.24	93.93
Isd 30	89.04cd	90.70bc	87.66cd	93.38a	90.38ab	90.50ab	92.40bc	92.93bc	89.74	93.91
I-93/93	90.83bc	92.14ab	89.83bc	91.65ab	89.76ab	90.69ab	89.15d	91.40c	90.95	91.97
I-110/93	86.45e	93.86a	85.97d	93.56a	90.25ab	91.22a	93.29b	95.79a	92.27	95.78
I-39/94	83.95f	87.21de	88.72cd	89.20bc	87.37c	86.55c	88.15d	85.58e	85.37	91.06
I-8/95	88.27de	93.56a	87.55cd	93.35a	87.03c	90.90ab	89.58d	92.72bc	90.05	91.09
LSD (5%)		1.91		2.85		1.49		1.66		NS
LSD (1%)		2.60		3.88		2.02		2.26		NS
SEm (±)		0.66		1.00		0.53		0.57		0.96

Table 4: Recovery per cent in juice of normal cultivated and water-logged sugarcane

Variety/Clone	Months									
	September 2001		October 2001		November 2001		December 2001		January 2002	
	N	WL	N	WL	N	WL	N	WL	N	WL
Isd 20	6.49h	10.03d	8.26e	10.96b	9.16e	10.85b	10.93ef	11.18cde	10.91	12.01
Isd 30	9.83de	11.31bc	10.00c	12.45a	10.56bc	11.54a	11.00de	12.18ab	11.51	12.76
I-93/93	10.94c	12.28a	10.35c	12.58a	10.95b	11.83a	11.59bcd	11.75bc	12.02	12.69
I-110/93	8.54f	11.68ab	8.37e	12.15a	10.33c	11.51a	11.57bcde	12.67a	11.25	13.05
I-39/94	7.36g	9.29e	8.92d	10.40c	9.91d	9.36e	10.33fg	8.44h	9.32	11.40
I-8/95	9.49de	11.95a	9.15d	12.57a	9.34e	11.82a	10.05g	11.95b	10.26	11.64
LSD (5%)		0.62		0.61		0.40		0.65		NS
LSD (1%)		0.84		0.64		0.55		0.89		NS
SEm (±)		0.20		0.17		0.14		0.23		0.24

N = Normal Cultivated Sugarcane; WL = Water-logged Sugarcane; Different letter indicates significance difference as per LSD at 5% level; NS = Not Significant

Table 5 : Reducing Sugars per cent in juice of normal cultivated and water-logged sugarcane

Variety/Clone	Months									
	September 2001		October 2001		November 2001		December 2001		January 2002	
	N	WL	N	WL	N	WL	N	WL	N	WL
Isd 20	1.06	0.55	1.08	0.44	0.65	0.28	0.45	0.20	0.22	0.15
Isd 30	0.80	0.32	0.85	0.29	0.32	0.22	0.28	0.20	0.24	0.15
I-93/93	0.30	0.21	0.35	0.17	0.47	0.33	0.37	0.23	0.33	0.14
I-110/93	0.95	0.38	1.08	0.33	0.26	0.18	0.16	0.11	0.23	0.09
I-39/94	1.30	1.21	1.15	1.51	0.52	0.93	0.42	0.94	0.63	0.59
I-8/95	0.70	0.30	1.04	0.94	0.52	0.31	0.50	0.29	0.59	0.25
Mean	0.8517a	0.4950b	0.9250	0.6133	0.4566	0.3750	0.3633	0.3283	0.3733a	0.2283b
LSD (5%)	0.23		NS		NS		NS		0.12	
SEM (±)	0.06		0.12		0.08		0.08		0.03	

N = Normal Cultivated Sugarcane ; WL = Water-logged Sugarcane; NS = Not Significant

Table 6: Growth and yield performance of normal cultivated and water-logged sugarcane

Variety/Clone	Tiller 1000 / ha		Millable Cane 1000 / ha		Yield (TCH)		% increase (+) or decrease (-) over normal cultivated cane	Ton sugar/ha (TSH)		% increase (+) or decrease (-) over normal cultivated cane
	N	WL	N	WL	N	WL		N	WL	
	Isd 20	140.3de	107.6f	111.7bc	84.9fg	68.0efg		59.4g	12.65 (-)	
Isd 30	159.0bc	125.5ef	110.0bc	73.3h	97.0d	64.5fg	33.50 (-)	10.69c	7.85def	26.57 (-)
I-93/93	156.4bcd	142.8cde	106.4cd	98.9de	71.8ef	65.3fg	9.05 (-)	8.27de	7.90def	4.47 (-)
I-110/93	183.3a	126.9e	136.7a	81.7gh	150.3b	99.5d	33.79 (-)	16.63a	12.35b	25.73 (-)
I-39/94	139.4de	127.3e	105.7cde	95.0ef	92.5d	77.8e	15.89 (-)	9.13d	7.57ef	17.08 (-)
I-8/95	169.4ab	137.3e	117.8b	101.0cde	162.8a	130.9c	19.59 (-)	16.09a	15.44a	4.04 (-)
LSD (5%)	18.19		10.77		10.98			1.46		
LSD (1%)	24.72		14.64		14.93			1.98		
SEM (±)	6.20		3.67		3.75			0.50		

N = Normal Cultivated Sugarcane ; WL = Water-logged Sugarcane; Different letter indicates significance difference as per LSD at 5% level;

cane yield was lower in different varieties ranged between 9.05-33.97% and sugar yield was also lower ranged between 4.04-26.57% than normal cultivated cane. Singh *et al.* (1980) evaluated some sugarcane varieties under waterlogged condition and found that the cane yield were significantly reduced by water logging.

Therefore it may be concluded that sugarcane growth and yield attribute showed significant different in normal and prolonged water-logged cultivation, but chemical quality like purity, recovery per cent were showed non significant in the month of January 2002.

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