

Effect of drought on nutrient utilisation, yield and quality of sugarcane (*Saccharum officinarum*) varieties

P. RAMESH¹

Sugarcane Breeding Institute, Coimbatore 641 007 (Tamil Nadu)

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ABSTRACT

An experiment was conducted during the main season (January-December) of 1996 and 1997 at Coimbatore to study the utilisation and uptake of nutrients in sugarcane (*Saccharum officinarum* L.) varieties as well as on yield and quality as influenced by drought during formative phase. Though drought treatments recorded higher concentration of plant nutrients, their uptake was significantly reduced compared with that of the control. There was not much decrease in the percentage of nitrogen and potassium, whereas it was evident in that of phosphorus at different growth phases of crop, being higher in drought treatments compared with the control. There was significant reduction in total dry-matter production (TDMP), percentage of cane sugar (CCS), and cane and sugar yields in drought conditions compared with the control. Among varieties 'Co 6304' recorded higher TDMP, uptake of N and K and cane yield, whereas 'Co 8208' recorded higher CCS percentage and sugar yield. Cane and sugar yields were significantly negatively correlated with decrease in percentage of phosphorus and positively correlated with that of potassium from tillering to grand growth (120-240 days) and from tillering to maturity (120-360 days) phases.

Key words: Sugarcane, Drought, Nutrient utilisation, Yield, Quality

Sugarcane yields have been found to increase directly with the amount of available water (Jones, 1980), and moisture stress especially at early stages (formative phase) was found to reduce the crop growth, cane yield and quality (Venkataramana *et al.*, 1986). The relationship between the moisture and nutrient availability and the uptake of

sugarcane has been studied by several workers in the past (Parashar *et al.*, 1978; Ingram and Hilton, 1986; Wiedenfeld, 1995). However, very little information is available on the nutrient content and utilisation of sugarcane varieties as influenced by drought during formative phase, especially in tropical Indian conditions. Hence the present experiment

Present address : ¹Senior Scientist, ¹Indian Institute of Soil Science, Bhopal 462 038

was initiated to study the effect of different levels of drought on the nutrient content and utilisation in four sugarcane varieties and their relationship with yield and quality.

MATERIALS AND METHODS

A field experiment was conducted during the main season (January-December) of 1996 and 1997 at Sugarcane Breeding Institute, Coimbatore. The soil was sandy clay loam with pH 8.2, low in available N (140 kg/ha) and P_2O_5 (18.5 kg/ha) and high in K_2O (360 kg/ha). The field capacity, permanent wilting point and bulk density of soil were 19.5%, 11.0% and 1.32 g/cc respectively. The experiment was laid out in split-plot design with 3 replications. The treatments comprised three levels of drought during formative phase (withholding irrigation designated severe drought, irrigation at 80% depletion of available soil moisture (DASM) designated moderate drought, and irrigation at 50% DASM designated control) in main plots, and four sugarcane varieties ('Co 8021', 'Co 419', 'Co 8208' and 'Co 6304') in subplots.

Sugarcane was planted in the first week of January in both the years. Common irrigations were given at the time of planting and 3 days after planting. Then up to 60 days, irrigations were scheduled at 50% DASM in all the treatments. The irrigation treatments were imposed from 60 to 150 days during formative phase (March-May), whenever the soil-moisture depletion in 15-30 cm depth reached the desired moisture level, the depletion pattern was monitored weekly by using neutron

soil-moisture probe (Troxler Model 4300). After 150 days, irrigations were scheduled at 50% DASM in all the treatments till harvest of crop. The total rainfall received during the crop period was 783 and 847 mm in 1996 and 1997 respectively. The plot size was 9.0 m x 6.0 m; sugarcane was planted at 90 cm spacing; a fertilizer dose of 220-62-120 kg N, P_2O_5 and K_2O /ha was applied; and other recommended cultural practices were followed in all the treatments. The plant samples were collected at 120, 240 and 360 days, representing tillering, grand growth and maturity phases respectively. The samples were oven dried and analysed for NPK in leaf, sheath and stem separately, and the nutrient utilisation and uptake were calculated.

RESULTS AND DISCUSSION

Drought treatments recorded higher concentration of NPK at all the growth phases compared with the control. However, these were significant only at 120 days for leaf N and sheath P (Table 1). The NPK content of varieties did not differ significantly at any growth phase. The concentration of the nutrients in the leaf and sheath decreased as the crop advanced from tillering to maturity, due to the production of internodes with low nutrient concentration. Environmental conditions like drought that reduced crop growth can increase tissue-N concentration (Clements, 1980; Wiedenfeld, 1995).

The mean percentage decrease in nitrogen (PDN) was 22.9% from 120 to 240 days, 17.7% from 240 to 360 days and 36.7% from 120 to 360 days (Table 2).

Table 1. Leaf N, sheath P and K contents (%) at 120 (tillering), 240 (grand growth) and 360 days (maturity) as influenced by drought levels in four sugarcane varieties (mean data of 2 years)

Treatment	Leaf N at days of			Sheath P at days			Sheath K at days		
	120	240	360	120	240	360	120	240	360
<i>Drought level</i>									
Severe	1.55	1.18	0.97	0.247	0.163	0.109	2.40	2.22	1.54
Moderate	1.49	1.14	0.95	0.245	0.157	0.110	2.47	2.19	1.51
Control	1.45	1.11	0.92	0.189	0.146	0.108	2.46	2.17	1.49
CD (P = 0.05)	0.08	NS	NS	0.032	NS	NS	NS	NS	NS
<i>Variety</i>									
'Co 8021'	1.54	1.15	1.04	0.214	0.162	0.101	2.45	2.20	1.54
'Co 419'	1.50	1.17	0.90	0.244	0.154	0.112	2.49	2.30	1.58
'Co 8208'	1.49	1.17	0.89	0.231	0.146	0.108	2.34	1.99	1.44
'Co 6304'	1.45	1.14	0.95	0.217	0.140	0.116	2.49	2.20	1.50
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Mean	1.49	1.15	0.94	0.226	0.152	0.109	2.44	2.18	1.51

Table 2. Decrease in nitrogen (%) of leaf and decrease in phosphorus (%) and potassium (%) of sheath at different growth phases as influenced by drought levels in four sugarcane varieties (mean data of 2 years)

Treatment	N decrease in leaf (%)			P decrease in sheath (%)			K decrease in sheath (%)		
	120-240 days	240-360 days	120-360 days	120-240 days	240-360 days	120-360 days	120-240 days	240-360 days	120-360 days
<i>Drought level</i>									
Severe	23.8	17.7	37.4	33.1	34.1	55.8	7.5	30.6	35.8
Moderate	23.4	16.6	36.2	35.9	29.9	55.1	11.3	31.0	38.8
Control	23.4	17.1	36.5	22.7	26.0	42.8	11.7	31.3	39.4
CD (P=0.05)	NS	NS	NS	6.1	5.9	6.4	NS	NS	NS
<i>Variety</i>									
'Co 8021'	25.3	9.5	32.4	24.3	37.6	52.8	10.2	30.0	37.1
'Co 419'	22.0	23.0	40.0	36.8	27.2	54.0	7.6	31.3	36.5
'Co 8208'	21.4	23.9	40.2	36.7	26.0	53.2	14.9	27.6	38.4
'Co 6304'	21.3	16.6	34.4	35.4	17.1	46.5	11.6	31.8	39.7
CD (P = 0.05)	NS	4.2	5.4	5.0	5.2	NS	NS	NS	NS
Mean	22.9	17.7	36.7	32.2	28.1	51.3	10.6	30.5	37.9

However, decrease in N was not significantly altered by different levels of drought. Among varieties, 'Co 8021' recorded the lowest decrease in nitrogen (9.5%) between 240 to 360 days, whereas 'Co 419' and 'Co 8208' recorded its higher decrease between 120 to 360 days. The reduction of the initial nitrogen levels (early growth phase) to minimal levels (harvest) indicate the effective utilization of the absorbed nitrogen. Since the decrease in N indicates the rate of utilization of the absorbed nitrogen from soil, it can serve as a useful tool in measuring the utilisation capacity of varieties at different stages (Perumal, 1989).

The mean decrease in phosphorus was 32.2, 28.1 and 51.3% from 120 to 240, 240

to 360 and 120 to 360 days respectively. Drought treatments recorded higher decrease in phosphorus compared with the control. It was lowest (24.3%) from 120 to 240 days and highest (37.6%) from 240 to 360 days in 'Co 8021'. The mean decrease in potassium was 10.6, 30.5 and 37.9% from 120 to 240, 240 to 360 and 120 to 360 days respectively. Its decrease was recorded more in control than under drought, thought they were statistically not different. Perumal (1989) reported that a higher K content at early growth phase and higher rate of decrease indicate higher utilisation of the absorbed K.

Severe and moderate drought during formative phase resulted in 26.0 and 15.2% reduction respectively in total day-matter

Table 3. Total dry-matter production (TDMP), nutrient uptake, commercial cane sugar (CCS), cane and sugar yields at harvest as influenced by drought levels in four sugarcane varieties (mean data of 2 years)

Treatment	TDMP (t/ha)	Nutrient uptake (kg/ha)			CCS (%)	Cane yield (t/ha)	Sugar yield (t/ha)
		N	P	K			
<i>Drought level</i>							
Severe	42.4 (26.0*)	178.5	48.7	299.5	9.68	83.6 (29.2)	8.09 (35.4)
Moderate	48.6 (15.2)	187.7	54.7	324.2	10.01	96.6 (18.2)	9.66 (22.9)
Control	57.3	205.5	64.8	369.2	10.62	118.1	12.54
CD (P=0.05)	5.3	8.4	4.6	16.2	0.48	8.1	1.24
<i>Variety</i>							
'Co 8021'	51.6	211.2	59.4	344.8	9.99	106.6	10.64
'Co 419'	42.4	155.7	51.8	293.9	9.75	84.1	8.19
'Co 8208'	49.3	180.6	58.9	315.3	11.01	99.0	10.89
'Co 6304'	54.4	214.8	52.9	379.6	9.65	108.0	10.42
CD (P=0.05)	4.7	7.1	3.9	13.8	0.62	6.9	0.98
Mean	49.4	190.5	55.7	330.9	10.10	99.4	10.06

Figures in parentheses are percentage reduction over control

Table 4. Correlation coefficient of decrease in percentage of N, P and K at different growth phases with CCS, cane and sugar yields

Parameter	Decrease in percentage of								
	N			P			K		
	120-240 days	240-360 days	120-360 days	120-240 days	240-360 days	120-360 days	120-240 days	240-360 days	120-360 days
CCS(%)	-0.167	0.334	0.362	-0.217	-0.052	-0.254	0.791	-0.710	0.385
Cane yield	0.104	-0.441	-0.540	-0.687	-0.274	-0.842	0.597	0.079	0.783
Sugar yield	0.037	-0.243	-0.310	-0.643	-0.234	-0.777	0.733	0.161	0.755

Figures above 0.532 and 0.661 are significant at $P < 0.05$ and $P < 0.001$ levels respectively ($n-2=12$)

production (TDMP) compared with control. Among varieties, 'Co 6304' recorded higher TDMP (54.4 t/ha) and 'Co 419' the lowest (42.4 t/ha) (Table 3). Drought treatments significantly reduced the uptake of NPK compared with control. Among varieties, 'Co 6304' recorded the highest uptake of N (214.8 kg/ha) and K (379.6 kg/ha), whereas 'Co 8021' recorded the highest uptake of P (59.4 kg/ha).

The commercial cane sugar (CCS) was significantly higher in the control (10.62%) compared with that under drought treatments. 'Co 8208' recorded the highest CCS (11.01%) and 'Co 6304' the lowest (9.65%). There was a significant reduction in cane yield in severe and moderate drought conditions (29.2 and 18.2% respectively) compared with the control. 'Co 6304' recorded the highest cane yield (108.0 t/ha). There was 35.4 and 22.9 % reduction in sugar yield in severe and moderate drought conditions respectively compared with the control. There was no significant difference in sugar yield among varieties, except 'Co 419' which recorded the lowest yield.

CCS was significantly positively correlated with decrease in percentage of K from 120 to 240 days ($r=0.791^{**}$) and negatively correlated with it from 240 to 360 days ($r=-0.710^{**}$) (Table 4). There was significant negative correlation (-0.540^*) between cane yield and decrease in percentage of N from 120 to 360 days. But both cane and sugar yields were significantly negatively correlated with decrease in percentage of P and positively correlated with that of K from 120 to 240 and 120 to 360 days. Perumal (1989) also reported that the decrease in percentage of K in sugarcane varieties plays an important role in influencing both cane and sugar yields.

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