SUGARCANE YIELD AND QUALITY AS INFLUENCED BY NITROGEN RATES AND IRRIGATION FREQUENCY

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Abstract

The influence of nitrogen fertilizer and irrigation on the yield and quality of sugarcane was investigated at the National Cereals Research Institute Badeggi in 2002-03 and 2003-04 seasons. The experiment of randomized complete block design with three replications consisted of nitrogen applied at the rate of 0, 120, and 240 kg/ha and irrigation scheduled at 1-, 2-, 3-, and 4- week intervals. Irrigation and nitrogen had favorable effects on growth and yield of sugarcane. The yield and yield characters were highest with irrigation at 1-week interval while nitrogen application (120 and 240 kg/ha) significantly increase the yield of cane. The effect of irrigation on cane quality was significant in the two seasons, but the difference in quality parameters due to nitrogen rate was only significant in 2001- 02. The highest dose of nitrogen (240 kg/ha) resulted in poor cane quality, never the less irrigation at 1-week interval gave the best quality. The interaction among nitrogen and irrigation was significant for cane yield in 2003-04 season.

Introduction

Like most major agricultural crops, sugarcane growth, yield and quality respond markedly to variation in moisture and nutritional availability. Nitrogen nutritional needs of the cane crop are typically met by the application of N fertilizer that plays important role in enhancing yield and quality (Muchovej and Newman, 2004). Environmental factors such as moisture availability do influence the amount of soil N utilized by sugarcane (Glaz, *et al*., 2000).

Nitrogen is the most essential element having direct effect on cane growth, sugarcane yield, and juice quality. Studies have established that N increase the quantity of green tops (Garside, *et al*., 2003), yield component, and yield of cane and sugar (Azzazy and Elgadaway, 2003). Similarly, Yousef *et al*., 2000 have shown that nitrogen has significant influence on cane growth, yield, quality and recoverable sugar. However, nitrogen application at rates exceeding sugarcane plant utilization has adverse effect on cane quality (Yadav *et al*., 1990).

Availability of water is an important factor causing variation in sugarcane yield and juice quality. According to Azzazy *et al*., (2000) water is the key to sugarcane growth, development and subsequent conversion of recoverable sugar to sucrose. While Qureshi *et al*., 2001 have reported that the amount of water utilized by cane plant has a linear relationship to total dry matter produced. A favorable soil water condition during cane growth also has a significant effect

on the yield and quality response of sugarcane to nitrogen fertilization (Bhatti *et al*., 1986). According to Taha, *et al*., (2003), meeting the nutrient and water requirements of sugarcane effectively makes the crop flourish and yield profitably.

Little information is available on the influence of nitrogen fertilizer on sugarcane yield and quality under various irrigation regimes. This knowledge is required to develop better fertilizer and irrigation practice in the crop. The objectives of this research were to determine the effect of nitrogen fertilizer and irrigation interval on cane yield, yield components and cane quality of sugarcane.

Materials and Methods

This study was conducted in the upland research field of the National Cereals Research Institute (NCRI) Badeggi (9^0 4' N and 06 07 E) on sandy soil classified as ultisol (Ayotade and Fagade 1993) in 2002-03 and 2003-04 growing seasons (the physical and chemical properties of the soil at the site is presented in Table 1). The experiment design is a three – replicated randomized complete block consisting of four nitrogen rates, viz 0, 120 and 240 kg/ha and irrigation applied at 1-, 2-, 3-, and 4- week's interval.

Table 1. Some Characteristic of the Soil at the Experimental Site 2002-03 and 2003-04 Seasons

COMPOSITION	2002-03	2003-04
Sand	90.900	91.000
Silt	7.990	8.000
Clay	1.000	1.000
Textural class	Sandy	Sandy
pH in H_20 (1:2.5)	5.200	6.200
Organic carbon (g/kg)	0.480	0.500
Organic matter	1.140	1.100
Total nitrogen	0.070	0.039
Available phosphorus (mg/kg)	7.870	8.950
Potassium	0.250	0.380
Magnesium	0.230	0.290
Calcium	1.200	1.000
Sodium	0.150	0.180
C.E.C	5.800	5.850

Gross plots, which were 5 m wide and consisting of six rows 10 m long with 1 m spacing between rows were planted on 23 Oct. 2002 and 26 Nov 2003. Nitrogen (urea 45 % N) was applied as per treatment in split, half within the furrows before planting and half as top dress at three months after planting

during earthing up. Irrigation was applied uniformly after planting until the crop established, then varied according to treatment. Recommended agronomic and plant-protection methods in line with the NCRI sugarcane production guidelines (Busari and Agboire, 1998) were employed during each growing season.

Each season, all sugarcane plots were harvested manually by cutting the stalks at ground level. Immature stalks (suckers) were discarded. After removal of their top four internodes, all remaining stalks were weighed to determine cane yield (t/ha) and counted. Millable cane length was recorded by measuring five full-length stalks taken randomly from each plot. For juice quality analysis, five stalks selected at random from each plot were crushed with a Jafco- cutter grinder to extract the juice. Brix the soluble solids concentration of the juice was determined with a Brix hydrometer, polarity (sucrose concentration) was measured using Bauch and Lomb polarimeter and commercial cane sugar was estimated using the formula adopted by Barnes (1974). Data collected were subjected to statistical analysis in accordance with the procedure of (PRO MIXED SAS Inst. 1985).

Results

Cane yield

The effect of nitrogen and irrigation on cane yield was highly significant in the two seasons (Table 2). A positive linear relationship between cane yield and nitrogen rate was observed in 2003-04 season. Although N application appeared to increase cane yield in 2002-03 season, differences due to application of 120 and 240 kg/ha were statistically non-significant. The data showed that the overall effect of irrigation treatment was to reduce cane yield for the two seasons. Consistent reduction in yield occurred as irrigation interval increased. Differences in cane yield due to nitrogen x irrigation interval interaction were only significant in 2003- 04 season (Table 3).

Table 2: Effects of Nitrogen Rate, Irrigation Interval and Their Interaction on Cane Yield and Its Components In 2002-03 And 2003-04 Seasons

	Millable cane length		No. of millable cane		Cane yield (t/h)	
Treatments	***2002-03***	***2003-04***	***2002-03***	***2003-04***	***2002-03***	***2003-04***
N rate (kg/ha)						
0	187.24b	171.17c	69732b	70568c	63.14b	46.56c
120	189.40b	182.07b	80232a	79200b	72.51a	55.19b
240	192.93a	195.88a	83232a	87032a	71.98a	62.26a
SE ±	1.74	2.44	2.78	2.06	1.00	0.67
Significance	**	**	**	**	**	**
Irrg. intval. (wk)						
1	213.17a	208.89a	87688a	84932a	83.56a	74.93a
2	200.93b	193.21b	86044a	83068a	78.94b	62.06b
3	185.56c	179.89c	74844b	77332b	62.77c	45.04c
4	159.80d	150.16d	62356c	70400c	51.56d	36.65d
SE ±	2.00	2.82	3.21	2.38	1.15	0.77
Significance	**	**	**	**	**	**
Interaction						
N x I	NS	NS	NS	NS	NS	**

Means followed by the same letter within a column of a treatment group are not statistically different. ** = significant at 1 % level. NS = not significant

Table 3: Nitrogen Rate And Irrigation Interval Interaction on Cane Yield In The 2003-04 Season.

Nitrogen level	Irrigation interval (week)			
(kg/ha)	1	2	3	4
	2003-04			
0	59.70d	54.74e	35.20h	36.61h
120	74.57b	65.89c	50.43f	29.86i
240	90.51a	65.56c	49.49f	43.49g
SE±	1.33			

Means followed by the same letter(s) in the same column and rows are not statistically different.

The result of the nitrogen x irrigation interaction in 2003-04 is presented in Table 3. The data showed that increasing the nitrogen rate was most effective in increasing cane yield at the highest frequency of irrigation (1– week). Cane yield recorded at 120 and 240 kg/ha nitrogen was significantly higher than 0 kg/ha at each interval of irrigation except at 4- week. Each increase in irrigation from 1- up to 4- week interval has resulted in a significant reduction in cane yield with nitrogen applied at 120 and 240 kg/ha.

Yield Characters

As shown in Table 2, nitrogen and irrigation had a highly significant influence on millable cane length in both seasons. In 2002-03 season, application

of nitrogen at 240 kg/ha resulted in significantly higher cane length compared to 0 and 120 kg/ha that are statistically comparable. However, in 2003-04 season, significant increases in millable cane length was observed with each addition in nitrogen rate. Increases in irrigation interval consistently resulted in a significant decrease in millable cane length in 2002-03 and 2003-04 seasons.

Differences in number of millable cane were highly significant due to the effect of nitrogen and irrigation in both seasons (Table 2). In 2002-03 season, raising the nitrogen rate from 0 to 120 kg/ha significantly increase millable cane number, but a further increase in N rate to 240kg/ha had no significant effect on the parameter. Number of millable canes was increased significantly with increased nitrogen rate from 0 up to 240 kg/ha in 2003-04 season. In 2002-03 and 2003-04 seasons, irrigation either at 1- to 2- weeks interval had no significant effect on the number of millable canes.

Differences in cane yield characters due to nitrogen x irrigation interaction were not significant in both seasons.

Cane Quality

The effect of nitrogen and irrigation on the quality of cane juice, as expressed by Brix, polarity and sucrose contents of the cane juice are presented in Table 4. The results show ed that nitrogen rate had no significant effect on all the cane quality attributes in 2002-03 season. The effect of nitrogen on the quality of cane juice was highly significant in 2003-04 season where the percentages of Brix, polarity and sucrose recorded at 0 kg/ha nitrogen was statistically at par with that at 120 kg/ha. Generally application of 240 kg/ha N seems to have caused greater significant reduction in quality compared to lower rates evaluated.

Table 4: Effects of N Rate, Irrigation Interval and their Interaction on Cane Quality in 2002-03 And 2003-04 Seasons

Treatments	Brix		Polarity		Sucrose	
	2002-03	*2003-04*	*2002-03*	*2003-04*	*2002-03*	*2003-04*
N rate (kg/ha)						
0	15.33a	16.50a	11.48a	12.85a	7.79a	8.91a
120	14.92a	16.83a	11.15a	12.99a	7.75a	9.03a
240	14.92a	15.67b	11.02a	11.70b	7.43a	7.99b
SE ±	0.20	0.19	0.27	0.18	0.14	0.14
Significance	NS	**	NS	**	NS	**
Irrg. intval. (wk)						
1	16.11a	17.28a	12.80a	14.12a	8.91a	10.53a
2	16.33a	17.00a	11.89b	12.75b	8.38b	8.72b
3	14.44b	16.06b	10.96c	12.37b	7.72c	8.47b
4	13.33c	15.00c	9.20d	10.82c	5.62d	6.86c
SE ±	0.23	0.22	0.31	0.21	0.16	0.16
Significance	**	**	**	**	**	**
Interaction						
N x I	NS	NS	NS	NS	NS	NS

Means followed by the same letter within a column of a treatment group are not statistically different. ** = significant at 1 % level. NS = not significant

The influence of irrigation on cane quality characters was highly significant in all seasons. (Table 4). Although increase in irrigation interval appears to reduce Brix in the two seasons, the difference in Brix due to 1- and 2-week irrigation interval were statistically non-significant. The data also showed that Brix and polarity diminish in a linear fashion with increasing interval of irrigation, the maximum reduction being at the longest interval in 2002-03 season. Similar trend was observed in 2003– 04, except that the decline in the parameters due to an increase in irrigation interval from 2- to 3– week was not significant.

The interaction between nitrogen and irrigation on all juice quality parameters was not significant in any of the seasons.

Discussion

The data showed that the effects of N fertilizer and irrigation on number and length of millable cane and cane yield are closely related. Differences in cane yield and its characters due to N application were noticeable with lower values observed at 0 kg/ha than at 120 or 240 kg/ha N. The positive and significant effect of N on number and length of millable canes, the characters consistently associated with sugarcane yield support previous findings (Yadav *et al*., 1990; Gascho,1986) about the positive influence of N on the crop. The significant response of yield attributes to N could be due to the effect of the element on crop growth. Govinda *et al*., (1971) reported that the influence of N on shoot development (LAI and tillers) at early growth phase greatly influence cane development and yield. In this study, the maximum increase in cane yield was due to application of 240 kg/ha followed by 120 kg/ha N. This shows an increasing trend in cane yield with increased N rate. Abd El-Gawad *et al*., (1992) reported that cane yield responded positively and significantly to N fertilizer up to 240 kg/ha.

The overall effect of irrigation treatment was a reduction of cane yield and its attributes. Muchow and Keating (1998) also reported reduction in cane yield with increase in irrigation interval as observed in this trial. The fact that yield decline was higher at longer intervals than at shorter intervals, indicates a strong relationship between water stress and yield decline as reported by Yahaya *et al.,* (2008). Along the same line, Kanwar *et al*., (1989) has documented the sensitivity of sugarcane growth and ultimate yield to soil water stress, while Prihar *et al*., (1985) reported that water deficit promotes pith formation in cane resulting in reduced yield.

The interaction showed cane yield decline with increased irrigation interval from short interval of 1- week to the longest interval of 4- week, irrespective of N treatment. Periods of water stress under an extended irrigation

frequency could have had a depressive effect on yield attributes as previously reported by Ismail *et al*., 2000. Furthermore, cane yield responses due to N application (120 and 240 kg/ha) was highest under 1-week irrigation interval than any other irrigation treatment. The significant variation in yield due to N application at different irrigation frequency, suggest that irrigation influence the uptake of N fertilizer and its subsequent utilization in yield formation. Yahaya *et al*., (2007) have reported that the beneficial effect of N on cane yield at shorter interval of irrigation could be the result of increases in LAI, above ground biomass and the production of significantly taller and more millable canes stalks due to N application.

The response of sugarcane to N in respect of quality was significant in 2003-04 where N applied at 240 kg/ha had a more detrimental effect on Brix than did the other two treatments, as was also the case with polarity and sucrose. Reduction in quality with N application beyond 120 kg/ha is the expected response to applied N when the element is supplied in excess (Yadav *et al*., 1990; Azzazy 1998). It has been hypothesized that increase rate of N make the cane plant more succulent and consequently dilute the sucrose concentration of the juice.

Furthermore, several workers have previously observed differences in cane quality due to irrigation (Robertson *et al*., 1999; Kumar *et al*., 1999). Generally, Brix, polarity and sucrose were adversely affected with increase in irrigation interval. Results reported by El-Gaddawy *et al*., (1997) indicated significant response of Brix and sucrose percentages due to irrigation. Water stress may be responsible for the significant response to irrigation treatment.

In conclusion, the study demonstrates a general positive relationship between increasing N fertilizer, short irrigation interval and cane yield. Results further revealed that excess N (240 kg/ha) and long interval of irrigation are detrimental to cane quality.

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