The influence of sowing date on growth, yield and qualityof sugar cane

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ABSTRACT

This study was conducted within the commercial field of New Halfa Sugar Scheme, during the period October 1994 to September 1996 to determine the influence of sowing date on sugar cane growth, yield and quality. Climatic elements including temperature, percent relative humidity (%RH) and total rainfall were obtained from Halfa meteorological substation. Soil moisture and actual evaportranspiration (ET) during the growth period were measured. Penman evaporation (E) was calculated. Gernnination percentage, plant population, plant height, stalk thickness, number of intenodes per stalk, fresh and dry mutter content, pithyness, flowering percentage, brix (%), purity (%), pol ،(%) recovery and fiber (%) were determined. The results showed that July and October planting dates were of signi- ficantly higher values for the different aspects of thermal time, crop factors, germination (%)
tiller-ing, (%), plant height, dry matter production, final yield and sugar quality as compared to the late sowing date in March. Pithyness was associated with March planting and decreased with July planting Flowering occurred only in the crop planted in March. The water requirements of the crop differed from the existing indenting system where about 18.6 m^3 /feddn(f)/day were required during initial stage, 24.3 m^3/ f/day were required during the development stage,/ 41.28 m^3/f/day were required during the mid season stage and 25.8 m^3/f/day were required during the late season stage whereas 31,6 m^3/f/day were required as an average for the whole cycle of cane plant. Sugar cane crop required about 314, 1274, 3092 and 4204 accumulated degree days for initiation, development, mid season and maturity, respectively, for optimal productivity. The late planting date in March exposed the crop to harmful effects of heat stress resulting in poor germination and low yield.

INTRODUCTION

Cane and its products hold a prominent place among tropical plants. The world produces more than 127 million tons of cane sugar annually. Sudan is one of many countries that cultivate sugar cane for production and this is because of the favourable environmental conditions. The crop is currently grown on an area of about 168000 feddans (l feddan (f) =0.42 hectares) to produce about 0.5 million tons of refined sugar annually.

New Halfa sugar estate is one of the major plantation areas of sugar cane in Sudan. It established in 1965 and located about 400 kilometers south east of Khartoum. The gross area of the scheme is about 40000f of which 22000f is annually planted with cane. The maximum capacity of the factory is 75000 tons of refined sugar per annum. The calimate is semi-arid, hot in summer and cool and dry in winter. The period from July to October is warm and rainy. The soil is a heavy clay soil. The scheme is irrigated from Khashm Elgirba Dam on Atbara River. The main problems facing cane production in the scheme include extension of sowing dates beyond the recommended dates, water logging and shortage, extended crushing season and pithyness of' canes.

Cane (*Saccharum officinarum L.)* is cultivated in hot tropical and sub tropical countries where the favorable climate for its growth are hot dry conditions without extremes of temperature and adequate watering and drainage. There are many factors which affect sugar cane growth and yield. They include in addition to soil physical conditions, climatological factors such as temperature and photoperiod (Edwards and Paxton, 1979). Mohammed (1987) reported that the optimum, sowing date for sugar cane production in Sudan was the second half of the calender year (July-December). The final report of committee for pithyness investigation in sugar cane, (FRCPS, 1992) stated that Pithyness was observed only in cane which flowered in both varieties.Yang (1976) reported that soil moisture content was one of the major factors affecting yield and sugar content.

Because high temperatures and water shortage are limiting factors to high yields in many parts of the semi arid and arid tropics and because sugar cane is a long season crop, this study was set forth to the following:

a) Determination of the optimum sowing date of the crop,

b) Quantification of crop water requirements under New Halfa conditions,
c) Determination of the thermal time requirements of the various phenological stages of sugar cane and,
d) Investigation of the pithyness problem in sugar cane.

MATERIALS AND METHODS

The experiment was conducted on a field at New Halfa sugar scheme during the seasons 1994/95and 1995/96 using a randomized complete block design with four replications. An area of I .4 f was divided into four blocks where each block contained eight plots. Four sowing dates were chosen to match the post rainy season (October), winter (December), early summer (March) and rainy season (July) and two main varieties, Co 527 and Co 6806. were planted. Tillage was adopted according to standard practices followed in the scheme. Phosphorus fertilizer (Triple super phosphate) was applied at the rate of 100kg/f before planting. The crop was planted as seed pieces in an overlapping manner in furrows and covered manually with a thin layer of soil. Irrigation was carried out immediately after planting. Gezapax and Gezaprim herbicides were applied before the second irrigation. After 3weeks of planting, subsequent waterings were applied every 15 days until a month before harvest. At the age of 3 months, the plots received nitrogen in the form of urea at rate of 200kg/f and was manually broadcast and followed soon with split-ridging. The total number of waterings until drying date was 25.

Physical measurements:

Daily air temperatures: were measured at the height of I .5 meters using maximum and minimum temperature thermometers.

Daily relative humidity (%RH) was measured using dry and wet bulb thermometers.

Daily rainfall was measured during the rainy season using a rainfall gauge.

Soil moisture content was determined gravimetrically and then converted to volumetric values through multiplication by dry soil bulk density.

Evaporation from open water surface (E) was calculated using Penman equation (Penman, 1948).

Evapotranspiration (ET) was measured and calculated as the sum of the water lost from the whole profile for the specific period.

Crop factors (ET/E) were calculated from gravimetric measurements

Thermal time requirements of sugar cane were calculated using equations used by Garcia-Hiudobro *et al*. (1982) and Mohamed *et a*l.(1988).

Biological parameters

Germination counts: The number of buds in every plot were counted immediately after planting. Counts of germination were then made every 15 days for 2 months. Final germination % and rate were then recorded.

Plant height and stalk thickness: Ten stalks were chosen randomly from the two inner rows of each plot. Lengths and diameter of stalks measured every 15 days. Stalk thickness measurements were taken 30 cm above the soil.

Fresh and dry matter contents of plant samples: Samples of five plants were randomly selected from each block (sowing date) every month. Fresh weight was determined using Mettlor balance. Plant samples were then oven dried at 85 C˚ and reweighed for the dry reweighed for day weight.

Pithyness (%): Five stalks were selected randomly from each block sowing date) every month. The total number of internodes in the sample were counted monthly and the number of the pithy internodes was then determined and the percentage of pithyness was calculated.

Flowering (%): The total number of stalks in the two inner rows of each plot were recorded every 15 days. immediately after flower initiation, the number of flowering stalks were counted in each plot in the two inner rows every 15 days. The percentage of the flowering stalks was then calculated.

Juice analysis: The most widely used terms in sugar industry to determine cane quality are polarization (POI) which refers to sucrose content of cane, brix, and purity. Following Spencer and Meade (1964) ten sugar cane stalks were selected from the two inner rows just before harvesting and sucrose (pol%), brix, purity and fiber percentages were determined. Estimation of solids in juice solution (brix %) was made by a hydrometer. Sugar content of sugar cane was determined by polarimeter. Purity of a solution containing sucrose is the proportion weight of sucrose to dissolved solids. Data was subjected to the analysis of variance procedure and can's Multiple Range Test to compare differences between treatments.

RESULTS AND DISCUSSION

Climate of the experimental site

Air temperature (C˚)

The mean monthly air temperatures for both the experimental site and New Halfa town during the growing seasons (1994/95) (1995/96) were not different. Averaged over all sowing dates, the main air temperature for the initial stage was 31˚C,29.5 C˚ for the development stage, 30˚C for mid season stage 29.5˚C for the late season stage (Table l). The mean air temperature was lowest in December sowing date and highest in March during the initial stage. For the development stage it was lowest in October and highest in March. For mid season stage it was lowest in July and highest in December For late season stage the temperature was highest in July and low March sowing dates. The mean temperature for the growing set was highest in March sown crop (31 ˚C) and lowest in December crop (29 C˚).

Relative humidity(%)

The study showed that RH % during the growing season1994/95 ranged from 43 to 75% while in season 1995/96 it ranged from 42 to %70and the highest %RH prevailed during the rainy months lowest occurred during the summer months (Table l). The RH% was highest in October sowing date and lowest in March during the initial stage. For the development stage, the RH% was highest in December and lowest in July. For the mid season stage it was highest in December and lowest in July. For the late season stage it was highest in October and lowest in March. No significant differences were observed between the site and New Halfa in RH% .

Total rainfall

The total rainfall of New Halfa town for seasons 1994/95 and 1995/96 was 234 and 384mm, respectively, while the experiment site recorded a total of 228 mm respectively. The total rainfall was more in New Halfa town than in the experimental site.

Table I shows that three of the four growing seasons received a total of 228 mm while one season received 248 mm.

Kvapotranspiration (ET crop) of sugar plant cane (mm/day)

The study showed that the amount of water used by plant cane crop differed with its growing stages. The average ET crop for July sowing date

increased from 5.1 mm/day at planting to 10.0 mm/day at full cover (7.5 months later) and decreased to 9.6 mm/day, towards maturity and ripening phase. Similar results were reported by Farbrother (1973) and Abd Elrasool *et al*. (1977) who found that the consumptive water use by cane increased gradually with the plant development and reached its peak during summer months but declined at the end of growing season. Similar trends in ET were reported by Chang (1979)

Table l. Mean air temperature (˚C), % relative humidity and total rainfall (mm) for the various cane growth stages for the different sowing dates.

Grow-ing Season	Initial stage		Develop stage		Mid Season stage		Late Season stage		Total Rainfall (mm)	Mean temp	Me an %R H
	Mean Air Temp	Mean RH%	Mean Air Temp	Mean RH	Mean Air Temp	Mean RH%	Mean Air Temp	Mean RH%			
Oct 94 Nov95	32	50	27	50	31	50	30	54	228	30.0	51.0
Dec94 Jan 96	27	45	28	56	32	56	29	45	228	29.0	50.5
Mar95 Apr 96	34	44	33	54	29	54	28	43	228	31.0	48.8
Jul 95 Aug96	30	65	30	45	28	45	31	47	248	29.8	50.5
Mean	30.8	51.0	29.5	51.3	30.0	51.3	29.5	47.3	233		
SE±	1.49	4.85	1.32	2.42	0.91	2.42	0.64	2.39	5.00	0.41	0.4

Crop factors (C.F)

The study showed that irrespective of sowing dates, the crop factor was low during the initial stage or seedling stage due to low ground cover with an average of 0.5 to 0.55. It then gradually increased with the leaf area and ground cover till about the end of the development

stage and early period of the mid-season stage with an average of 0.68 to 0.70. It reached its peak at the end of the mid-season stage with an average of 1.00 to 1.20 and then decreased progressively during the late season stage with an average of 0.6 to 0.8 (Table 2). Adam (1992) reported that the magnitude of crop factors depend on varieties, planting date and on the

length of the growing season. Crop factors were comparable to those reported by Mirghani (1994) for Gunied scheme.

Table 2a. Average crop factors for various cane growth stages an different sowing dates for the two varieties Co 527 and Co 6806.

Sowing dates	Average crop factors				
	Initial stage	Develop Stage	Mid season Stage	Late season stage	Mean
Oct. 94	0.55	0.68	0.15	0.70	0.70
Dec. 94	0.50	0.70	1.20	0.80	0.80
Mar. 95	0.50	0.70	1.00	0.70	0.70
Jul. 95	0.50	0.70	1.10	0.60	0.73
Mean	0.51	0.67	1.11	0.70	0.75
SD±	0.02	0.03	0.07	0.07	0.04

Crop water requirements (m^3/f/day)

Table (2b) shows that the crop water requirements (CWR) values increased from 18.6 m^3/f/day at the initial stage to 24.3 m^3/f/day at the development stage. It reached its maximum of 41.3 m^3/f/day at mid season due to vegetative growth and then declined at the late season stage to 25.8 m^3/f/day during maturity. Results showed that there was significant difference ($P \leq 0.05$) between the calculated CWR and the water supplied during the growing seasons especially during the early stages of growth (October to January) where the calculated CWR was 31 6.m^3/f/day and the released CWR was 33.0 m^3/f/day. The study also indicated a significant difference ($P \leq 0.05$) between water requirement of plant cane of Gunied and New Halfa sugar schemes, where New Halfa scheme used more water that amounted to 33.0 m^3/f/day compared to 30.0 m^3/f/day used in Gunied scheme (Mirghani, I994). Similar trends in water use by sugar cane were reported by Fad1.(1977).

Table 2b. Crop factors and crop water requirements for the experimental site, an example for the sowing date in October 1994.

Months	Crop factors (C.F)	Crop water requirements(m^3/f/day)
Oct, 94	0.54	18.60
Nov. 94	0.67	19.00
Dec. 94	0.88	25.00
Jan. 95	1.00	29.00
Feb 95	I .04	43.00
Mar. 95	1.05	35.80
Apr. 95	I .07	43.60
May 95	1.08	44.20
Jun. 95	1.09	46.30
Ju195	1.20	43.80
Aug. 95	0.95	31.70
Sept. 95	0.88	26.00
Oct. 95	0.75	24.00
Nov. 95	0.70	21.70

Biological parameters

Germination time course and its thermal time requirements

The study showed that there were significant differences in the germination percentage between sowing dates ($P \leq 0.05$) and that the highest germination % was obtained in October and the lowest value was obtained in March planting (Table 3). It was found that 600 ˚Cd were requited for 50% germination of cane plants and that 13650Cd were required for completion of the germination process.

Time course of tillering and thermal time requirements

Results showed that there was a significant difference ($P \leq 0.05$(between sowing dates in tillering and that the highest number of tillers was obtained from the crop planted in July and the lowest number was obtained in March sowing date (Table 3). It was found that 2300 ^{O}Cd were required for completion of plant tillering.

Pithyness%

The results showed that pithyness was present irrespective of sowing date with varying percentages (Table 3). March planted crop the highest percentage of pithyness compared to other sowing dates. There was a significant difference ($P \leq 0.05$) between sowing dates and varieties. Pithyness started to develop in March sown crop after about 125 days from

planting and about 210 days in July sown crop. Pithyness was lowest in July sown crop. October and December sowing gave intermediate values. The results also showed that flowering was not the only factor that affected pithyness but also other factors notably high temperature and low %RH were involved.

Flowering 0/0

Flowering was observed on cane planted in March. Most of flowering in both varieties started about 7.5 months after planting this had extended for about 4.5 months and then it leveled off high flowering (%) contributed remarkably to low yield of cane sugar.

Time course of dry matter production (DM) and thermal t requirements

The amount of dry matter production increased gradually and reached 230 g/plant after 390 days from planting. There was significant difference between sowing dates in dry matter production ($P \leq 0.05$). The July, March and October sowing dates produced high dry matter due to high temperatures while December planting date produced the lowest DM due to low temperature (Table 3). The average thermal time requirements for the two varieties and for all sowing dates for initiation, development, mid season and maturity were 314 (±21.1)3092 (±12.9) 1274 (±48.8) and 4204 (±65.2) ^{0}cd, respectively.

Table 3. Means of cane growth parameters for the different sowing dates of the varieties CO 527 and CO 6806.

Sowing dates	Germi-Nation %	Number Of Tillers/m	Plant Heigh (cm)	Stalk Thick Ness(cm)	Dry matter Production (g/plant)	Pith-Ness (%)	Thermal Time (^{0}Cd)
Oct. 94	87.0a	18.0b	146.3 b	4.0b	200c	08.5b	4199
Dec. 94	75.0b	19.0b	141.6 c	3.5b	190b	09.3b	4121
Mar. 95	65.0c	15.0c	133.5 b	3.0c	215b	11.5a	4279
July. 95	85.0a	27.0a	151.5 a	4.5a	230a	06.3c	4218
Mean	78.0	20.0	143.2	3.8	209	08.9	4202

Means in the same column having the same letter (s) are not significantly different at the probability of 0.05 according to Duncan's Multiple RangeTest (DMRT).

Yield components

The results showed significant differences in cane yield between dates ($P \leq 0.05$). The highest cane and sugar yields were obtained in July due to favorable environmental factors and the lowest in March (Table 4).

Juice analysis

The results showed a significant difference ($P \leq 0.05$) between the various sowing dates in brix, purity, POI, recovery and fiber % where October planting date gave the highest brix and purity% while March planting date gave the lowest % of brix and purity. July planted crop had the highest sugar content and consequently recoverable sugar% and the lowest fiber% while March planted crop scored the lowest% of pol and consequently lowest recoverable sugar % and highest % of fiber (Table 4).

Table 4. Means of cane yield and juice parameters analysis for the different sowing dates of the varieties CO 527 and CO 6806.

Sowing dates	Cane Yield/f (tons)	Sugar/f (tons)	Brix (%)	Purity pol (%)	(%) Re-Covery (%)	Fiber (%)	
Oct94	38.8c	3.8b	21.1a	87.2a	13.2b	10.0b	15.0b
Dec94	40.9b	4.1d	20.6ab	85.7a	13.5b	09.8b	14.7b
Mar95	35.8d	3.0c	18.6c	80.8b	11.1c	08.0c	18.5a
Jul95	44.9a	4.4a	20.1b	86.1a	14.8a	10.8a	15.2b
Mean	40.0	3.8	20.1	85.1	13.3	09.8	15.9

Means in the same column having the same letter (s) are not significantly different at the probability of 0.05 according to Duncan's Multiple Range Test (DMRT).

It is concluded from the results that the optimum sowing date is July and the thermal time required for sugar cane crop to reach maturity about 4154 ^{O}Cd irrespective of sowing dates. Flowering was observed only in cane planted in March and pithyness was present in all sowing dates and it was more in the flowered cane planted in March. To reduce flowering percentage and pithyness and achieve the highest yield, it is recommended to start planting the crop during July.

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