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Yield and Yield Attributes of Sugarcane Under Deficit Irrigated Subsurface Drip Irrigation

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Abstract **– A field experiment was conducted to investigate effect of mulch, irrigation regimes and irrigation intervals on yield attributes of sugarcane under subsurface drip during the year 2014-2016 at Post Graduate Research Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri (M.S.) India. Present investigation revealed that the important yield contributing characters *viz.* periodical height of millable cane, number and length of internodes and their girth were significantly increased with incorporation of mulch treatments (M_1). Similarly all the attributes were increased with increasing irrigation regimes from 40 (I_3)to 80% ETc(I_1) and lowering the irrigation interval from 5 (D_3) to 2 days(D_1). But, many of the parameters were at par with 60% ETc(I_2)and 3 days (D_2) irrigation intervals. Periodical length and girth of internodes increased with decreased irrigation regimes. The cane and sugar yields of plant cane, ratoon cane and pooled data were significantly higher in mulch treatment. Similarly, cane and sugar yields during all the seasons were higher in 80% ETc irrigation regime and 2 days irrigation interval but cane yield at 60% ETc was at par with 80% ETc irrigation regime and 3 days irrigation interval was at par with 2 days irrigation interval. The sugar yield data was non-significantly affected due to any of the treatments in pooled analysis.**

Keywords **– Trash mulch, Irrigation regimes, Irrigation intervals and yield**

I. INTRODUCTION

Sugarcane is important cash crop of India. The area under sugarcane during 2014-15 in India was 5.09 M ha with average productivity of 70.93 t ha^{-1} and total production of 3610 lakh MT which contributes 19.60% of world's total production [1].Whereas, the state of Maharashtra (M.S.) was having 1.054 M ha area under sugarcane with production of 89.42 MT and average productivity as 84.26 t ha^{-1} [2]. However, the productivity of sugarcane in Maharashtra is continuously decreasing during last two decades due to poor irrigation management practices. Maharashtra state has 80 to 84% rainfed agriculture and one-third of the state falls under the semi-arid climatic zone. Deficient rainfall is reported once every 5 years and drought conditions have occurred once every 8-9 years in past. The irrigated area in the state is very low (16%) as compared to the national average of 42% [3]. The major problem to sugarcane agriculture in the region is the lack of assured water supply and the tendency of farmers to use that scarcely available water through conventional methods of irrigation.

In surface method, 19-23 per cent water is lost due to deep percolation in the field and 30-35 per cent losses are in conveyance [4]. The advanced micro-irrigation methods introduced recently such as drip, micro-sprinkler and subsurface drip help to increase water productivity significantly. The results of experiments showed that water saving from drip varies from 12 to 84 per cent [5]. For sugarcane, 40-50% saving of water and 20-25% increase in yield was observed due to drip irrigation in Maharashtra [6]. Its merits like water saving, yield increase, quality improvement [7] make it an ideal irrigation method for sugarcane. Similarly, irrigation method like subsurface drip offers many advantages over surface drip irrigation such as; reduced evaporation losses, efficient water use, greater water application uniformity, enhanced growth, crop yield and quality [8].

In addition to irrigation methods mulches plays vital role in moisture conservation. Mulches decrease soil water evaporation, maintains uniform soil moisture content and thus, reduces the dose of irrigation water. It avoids the fluctuations in temperature in the first 20–30 cm depth in soils, promotes root development, faster crop development and earlier harvest [9]. Considering the importance of organic mulches, sugarcane trash was used as mulch for this investigation. Ten tonnes of sugarcane trash are equal to 65 Kg of urea, 67.5 Kg of single superphosphate and 330 Kg of muriate of potash [10]. Thus, subsurface drip irrigation and mulching have taken into consideration with objectives as to study the yield contributing characters and cane and sugar yield under deficit conditions.

II. MATERIALS AND METHODS

The experiment was carried out in strip-split plot design with three replications. It consisted of two main treatments (mulchand no-mulch), three irrigation regimes (80% ETc, 60% ETc, 40% ETc), three irrigation intervals (2, 3 and 5 days irrigation interval) and surface irrigation as control treatment. The nine month old single eye bud setts of sugarcane cv.Phule-0265 were planted at 0.6-1.2 x 0.3 m spacing in paired rows with row to row spacing of 0.60 m and paired to pair spacing of 1.2 m. The sugarcane setts were placed at 0.05 m below the laterals of the subsurface drip. The laterals in subsurface drip irrigation were buried at 20 cm depth below the soil surface. To achieve advantage from the mulch, the sugarcane trash mulch applied 6 weeks after planting of crop @ 5 t ha^{-1} in 10 cm thickness in plant and ratoon cane. The recommended fertilizer dose for plant cane and ratoon was applied through the water soluble fertilizers as urea and urea phosphate (17:44:00) and muriate of potash @ 200:92:92kg ha^{-1} in 13 equal splits at 15 days interval in subsurface drip treatments. Regarding surface irrigation, the recommended dose of fertilizer

(250:115:115 kg N, $P_2O_5$and K_2O ha^{-1}) was applied in the form of conventional fertilizers as urea, single super phosphate and muriate of potash. The 50% of phosphorous and potash were applied at the time of planting and remaining 50% at 16 weeks after planting in control method. The nitrogen was applied in four splits as 10% at planting, 40% after 4 weeks, 10% after 12 weeks and remaining 40% at 16 weeks after planting.

The irrigation scheduling was done at 2, 3 and 5 days intervals according to ETc values of 80, 60 and 40%. The pan evaporation of 2, 3 and 5 days was considered to estimate the requirement of 2, 3 and 5 days irrigation interval, respectively. The water application was estimated by the following formula [11].

$$ETc = Ep * Kp * Kc$$

In which,

ETc = Evapotranspiration of crop (mm/days)
Ep = Pan evaporation (mm)
Kp = Pan factor (0.7),
Kc = Crop coefficient (stage wise)

Whereas, the water requirement was worked out as,

$$WR = ETc * Wa \text{ [12]}$$

Where,

WR = Actual evapo transpiaration of crop (mm)
Wa = Wettable area (60 per cent)

$$Gross\ WR = Ep * Kp * Kc * Ls * Es * \frac{Wa}{Irrigation\ efficiency\ (0.9)}$$

Where,

Gross WR = Water requirement, (lit)
Ls = Spacing between two laterals (m)
Es = Spacing between two emitters (m)

The Kc values were estimated at 15 days intervals considering the value of 0.4 for tillering stage, 1.25 for grand growth stage and 0.7 for maturity stage of sugarcane crop [13]. Irrigation water applied for surface irrigation method (control treatment) was measured (lit min^{-1}) with the help of Replogle flume at the head of water channel. The irrigation was scheduled on the basis of climatologically approach of 75 mm CPE in control treatment during plant and ratoon cane, respectively. The quantity of water to be applied per plot was calculated considering the available water holding capacity and effective root zone depth of the soil and the time required for irrigating the plot using area-depth relationship as,

$$T = \frac{(A * D)}{Q}$$

Where,

T = Time of water application (min)
A = Area to be irrigated (m^2),
D = Depth of irrigation (m)
Q = Discharge of water (lit min^{-1})

Finally total discharge in M^3 (A x D) was converted in litre the yield contributing characters like number of milliable canes, height of milliable cane, number of internodes, length of internodes and girth of internodes was recorded at 180, 240, 300 days and at harvest of sugarcane crop in plant and ratoon cane. The sugar yield was estimateted by using the following formula [14].

$$Sugar\ yield\ (t\ ha^{-1}) = \frac{Cane\ yield\ (t\ ha^{-1})}{100} * 100$$

III. Results and Discussion

***Effect of mulch*:** All the yield contributing parameters in plant and ratoon cane were significantly higher in mulch than no-mulch (Table 1). The higher millable cane height in mulch might be due to relatively higher moisture reserve and better weed suppression. The higher tiller production with higher survival capacity under subsurface drip system might have helped to get uniform millable canes. Similarly, higher value might be due to better and early conversion of tillers to millable canes otherwise which might have resulted in excess production of tillers in the early stages and would have diverted the plant nutrients unnecessarily for unproductive purpose [15] and [16].

Highest number, length and girth of internodes in mulch treatment was due to conservation of more soil moisture by reducing the evaporation from soil, maintenance of low soil temperature and suppression of weed growth under trash mulching [17].

The significantly highest cane and sugar yield was observed under mulch treatment in plant and ratoon cane (Table 9). The pooled means showed 5.6% and 18.2% more yield in mulch than no-mulch and control treatment, respectively. The higher production of sugarcane led to the higher sugar production in mulch treatment of subsurface drip irrigation [18].

Effect of irrigation regimes: The height of cane was increased from 180 days to the harvest in plant cane (171.8 to 331.8 cm) and ratoon cane (138.58 to 288.01) and the tallest millable cane was achieved in 80% ETc irrigation regime. The lowest millable cane height was observed in 40% ETc (266.9 cm) irrigation regime. The water deficit during the entire growth and especially in the mid-season stage caused a lower rate of stalk elongation [19] and [20].

At every observed stage in plant cane, the 40% ETc irrigation regime had lowest internodal length, but the internodal length in 60% ETc regime was at par with the 80% ETc irrigation regime. The moisture stress reduces the internodal length and occurrence of severe moisture stress especially at grand growth stage drastically affects the size of internodes. The cell division and cell expansion affected by water stress mainly reduces the plant elongation rate in lower irrigation regimes [21] and [22].

The significantly highest girth of internodes in 80% ETc irrigation regime was observed at all observed stages. However, the girth in 60% ETc was at par with 80% ETc in almost all the stages during plant as well as ratoon cane. The 40% ETc irrigation regime registered lowest internode girth. The characteristic effect of water stress on sugarcane in the form of reduced cane girth [23].

The 80% ETc irrigation regime produced significantly highest cane yield in plant cane (147.76 t ha^{-1}) and ratoon (149.12 t ha^{-1}). The sugarcane yield under 60% ETc irrigation regime (144.51 t ha^{-1}) was at par with the 80% ETc regime in plant cane and pooled means. The 40% ETc irrigation regime produced significantly lowest yields (132.22 t ha^{-1}). Almost all the processes of plant require

sufficient amount of water and its deficit in any process adversely affects the growth, development as well as cane yield as most of the processes are interlinked. Excessive irrigation reduces yield, while inadequate irrigation causes water stress and reduces production [24]. Similarly, as the soil moisture with higher irrigation regimes increased the optimal conditions in respect of nutrients, air, temperature, light, CO_2 and other factors of production, it responded progressively to increased cane yields with ETc levels [25].

Effect of irrigation intervals: In both the seasons of sugarcane, 2 days irrigation interval attained higher millable cane height due to the adequate soil moisture, more nutrients uptake and higher photosynthetic rate in this treatment as canes were not subjected to water stress [26] and [27]. However, the 3 days irrigation interval was remained at par with 2 days irrigation interval at all the days of observations in plant cane and at 180 and 240 DAR in ratoon cane.

The minimum girth of internodes was observed in 5 days irrigation interval in plant as well as in ratoon cane. This was expected because irrigation interval of 2 and 3 days had adequate soil moisture for growth and development. Canes subjected to water stress often have shorter internode lengths [17].

The cane and sugar yield was significantly maximum with 2 days irrigation interval in both seasons and was at par in 3 days interval of irrigation [28] and [29].

Effect of interactions

Mulch x irrigation regimes: The maximum millable cane height was attained in 80% ETc irrigation regime in mulch treatment of both plant and ratoon cane. In plant cane, 60% ETc irrigation regime with mulch (183.5 and 342.5 and 262.98 cm) was at par with 80% ETc irrigation regime with mulch at 180 and 300 DAP in plant and at 300 DAR in ratoon cane, respectively (Table 2).

The Table 4 indicates 80% ETc regime with mulch had maximum internodes than other interactions at 180 days after planting (DAP). At 240 DAP in plant cane and 180 days after ratooning (DAR) in ratoon cane, irrigation regime of 80% ETc with mulch combination (M_1I_1) was at par with 60% ETc irrigation regime with mulch (M_1I_2). The maximum length of internodes was observed in combination of mulch with 80% ETc (9.27 cm) but it remained at par with 60% ETc irrigation regime (Table 5). The 80% ETc irrigation regime under mulch recorded significantly higher cane girth at 180 DAP and remained at par with 80% ETc without mulch (12.50 cm) at 180 DAP and with 80% ETc without mulch (14.53 cm) and 60% ETc with mulch (14.61 cm) at harvest of plant cane (Table 8). Moisture conservation by reducing evaporation to some extent in mulch is demonstrated by producing at par results with lower irrigation regimes under mulches.

Mulch x Irrigation intervals: The millable cane height increased with decreased irrigation intervals. The maximum millable cane height was observed in 2 days irrigation interval; however, at 300 DAP of plant cane and harvest of ratoon cane, 3 days irrigation interval with mulch was at Par with 2 days irrigation interval.

The interactions of 2 days irrigation interval with mulch (15.56 and 21.67) had significantly more number of internodes at 180 and 240 DAP, respectively in plant cane than 3 and 5 days irrigation intervals; however, at 240 DAP, 3 days irrigation interval remained at par with 2 days irrigation interval with mulch. The interactions effect in respect of ratoon and pooled analysis were non-significant.

The interaction effect of mulch with irrigation intervals in respect to inter nodal length was non-significant in plant and ratoon cane except at 180 DAR in ratoon crop. The 2 days irrigation interval had maximum length of internodes (9.22 cm), but it was at par with the 3 days irrigation interval (8.87 cm) with mulch and 2 days interval without mulch. Irrigations at 2 days interval with mulch showed maximum internode girth at 180, 240, 300 DAP and at harvest. But at 6 and 8 month, the 2 days irrigation interval was at par with 3 days irrigation interval with mulch combination.

Irrigation regimes x Irrigation intervals: It was observed that 80% ETc irrigation regime with 2 days irrigation interval attained significantly maximum millable cane height in all stages; however, it remained at par with 80% ETc with 3 days irrigation interval (I_1D_2) at 180, 300 days and harvest and 60% ETc irrigation regime with 2 days irrigation interval (I_2D_1) at 300 DAP and at harvest in plant cane and at 240 DAR in ratoon cane.

Significant interaction in respect of the girth of internodes was observed at 180 DAP and at harvest in plant cane and 180 and 240 DAR in ratoon cane. In plant cane, maximum internodal girth was obtained by 80% ETc irrigation regime with 2 days irrigation interval (12.87 cm) and remained at par with 80% ETc + 3 days (12.62 cm) at 180 DAP in plant cane. Similar trend was observed in ratoon cane.

Mulch x Irrigation regimes x Irrigation intervals: The interactions between mulch, irrigation regimes and irrigation intervals were significant in plant cane at 180, 240 and300 DAP in respect of plant height. The 80% ETc irrigation regime+ 2 days irrigation interval with mulch (186.7, 240.4 and 355.8 cm) combination attained maximum millable cane height at 180, 240 and 300 days, respectively.

Only at the age of 240 DAP in plant cane, significant effect was observed in respect of internodal length. At this stage, length of internodes in 80% ETc + 2 days irrigation interval + mulch (23.00 cm) was superior over all the combinations. The combination of 80% ETc + 2 days irrigation interval in mulch recorded significantly higher cane girth but was remained at par with the 80% ETc + 3 days irrigation interval inmulch at 180, 240 DAP and at harvest.

IV. Conclusion

The maximum cane yield was observed in 80% ETc irrigation regime (148.44 t ha^{-1}) but was at par with 60% ETc regime (143.65 t ha^{-1}). Similarly, the cane yield in 3 days irrigation interval (145.43 t ha^{-1}) was at par with 2 days (147.85 t ha^{-1}) interval. The higher values in respect of all the yield attributing characters were observed in 80% ETc irrigation regime, 2 days irrigation interval and in mulch; but, at many of the observation stages the lower levels have produced statistically at par values of the yield contributors.

The almost similar trend throughout the crop growth

stages during both the seasons and in pooled data was observed.

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APPENDICES

Table 1. Periodical millable cane height (cm) as influenced by various treatments

Treatments	Plant cane				Ratoon cane				Pooled mean
	180 DAP	240 DAP	300 DAP	Harvest	180 DAR	240 DAR	300 DAR	Harvest	
Mulch									
M_1 : Mulch	180.45	210.58	336.96	345.52	140.40	191.52	271.07	277.56	311.54
Mo : No-mulch	151.21	177.16	291.90	300.53	133.88	166.85	245.12	251.83	276.39
SE (m)±	0.41	1.93	0.27	1.05	1.07	2.84	1.26	1.71	1.73
CD at 5%	2.49	11.75	1.63	6.42	6.50	17.26	7.67	10.40	6.78
Irrigation regimes									
I_1: 80% ETc	171.83	204.92	326.01	331.84	138.58	196.06	280.12	288.01	309.93
I_2: 60% ETc	169.97	198.49	320.37	331.31	137.40	179.80	271.73	277.76	304.54
I_3: 40% ETc	155.69	178.20	296.91	305.62	135.44	161.70	222.43	228.31	266.97
SE (m)±	0.66	1.16	1.22	1.55	0.56	4.17	3.67	3.52	3.33
CD at 5%	2.61	4.57	4.80	6.07	2.20	16.36	14.42	13.80	10.86
Irrigation intervals									
D_1: 2 days	168.77	201.35	319.65	327.18	142.48	197.62	287.82	293.71	310.45
D_2: 3 days	168.36	199.70	318.23	327.09	138.01	178.89	259.81	267.10	297.10
D_3: 5 days	160.35	180.56	305.41	314.81	130.93	161.05	226.64	233.28	274.04
SE(m)±	0.67	1.05	1.37	1.36	2.70	3.40	4.19	3.96	3.63
CD at 5%	1.95	3.07	4.00	3.96	7.89	9.93	12.23	11.57	10.33
Interactions									
Mulch X irrigation regimes									
SE(m)±	0.87	0.73	1.91	2.31	6.25	0.85	2.00	2.84	3.17
CD at 5%	Sig.	Sig.	Sig.	NS	NS	Sig.	Sig.	NS	NS
Mulch X irrigation intervals									
SE(m)±	0.94	1.49	1.94	1.92	3.82	4.81	5.93	5.61	5.14
CD at 5%	Sig.	Sig.	Sig.	NS	NS	NS	NS	Sig.	NS
Irrigation regimes X irrigation intervals									
SE(m)±	1.16	1.82	2.37	2.35	4.68	5.89	7.26	6.87	6.29
CD at 5%	Sig.	Sig.	Sig.	Sig.	NS	Sig.	NS	NS	NS
Mulch X irrigation regimes X irrigation intervals									
SE(m)±	1.63	2.57	3.35	3.32	6.62	8.33	10.26	9.71	8.90
CD at 5%	Sig.	Sig.	Sig.	NS	NS	NS	NS	NS	NS
Control									
SI: Surface	111.01	160.37	214.32	231.74	124.84	178.76	212.26	217.27	224.51
General mean	165.83	193.87	314.44	323.03	137.14	179.18	258.09	264.70	293.96

Table 2. Interaction effects on mean millable cane height

Interactions	Plant cane						Ratoon cane					
	180 DAP		240 DAP		300 DAP		240 DAR		300 DAR		Harvest	
	M_1	Mo	M_1	Mo	M_1	Mo	M_1	Mo	M_1	Mo	M_1	Mo
Mulch x Irrigation regimes												
I_1: 80% ETc	183.9	160.1	220.4	189.3	345.1	306.8	204.3	187.8	293.5	266.7		
I_2: 60% ETc	183.5	156.0	217.3	179.6	342.5	298.1	198.7	160.8	280.4	262.9		
I_3: 40% ETc	173.8	137.5	193.9	162.4	323.1	270.6	171.4	151.9	239.2	205.6		
SE(m)±	0.87		0.73		1.91		0.85		2.00			
CD at 5%	3.42		2.86		7.50		3.36		7.85			
Mulch x Irrigation intervals												
D_1: 2 days	183.1	156.5	218.5	188.8	340.4	299.6					298.1	289.2
D_2: 3 days	180.1	154.4	213.8	180.8	339.6	296.0					285.9	248.2
D_3: 5 days	178.0	142.7	199.3	161.8	330.7	280.0					248.5	218.0
SE(m)±	0.94		1.49		1.94						5.61	
CD at 5%	2.75		4.34		5.65						16.37	
Mulch x Irrigation regimes x Irrigation intervals												
I_1D_1	186.7	171.8	240.4	205.3	355.8	318.6						
I_1D_2	185.4	164.3	225.4	204.6	350.0	309.7						
I_1D_3	181.4	153.3	208.0	164.6	336.6	299.4						
I_2D_1	184.3	156.8	221.8	199.0	346.0	307.2						
I_2D_2	183.7	155.1	218.4	169.0	340.9	302.5						
I_2D_3	178.9	143.7	196.8	164.3	324.4	275.7						
I_3D_1	180.6	146.8	199.1	168.8	333.4	277.5						
I_3D_2	171.9	140.8	194.3	162.0	322.8	272.9						
I_3D_3	170.7	127.9	190.6	156.4	322.2	263.1						
SE(m)±	1.63		2.57		3.35							
CD at 5%	4.77		7.51		9.79							

*DAP= Days after planting and DAR= days after rationing

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Table 3. Number of internodes of sugarcane as influenced periodically

Treatments	Plant Cane				Ratoon Cane				Pooled Mean
	Days After Planting				Days After Ratooning				
	180	240	300	Harvest	180	240	300	Harvest	
Mulch									
M_1:Mulch	14.98	21.15	25.14	28.43	13.89	20.98	23.90	26.43	27.43
Mo: No mulch	13.75	19.96	24.96	28.28	13.56	19.94	23.27	25.78	27.03
SE (m)±	0.05	0.18	0.02	0.12	0.05	0.03	0.05	0.09	0.13
CD at 5%	0.33	1.12	0.14	NS	0.33	0.18	0.32	0.56	NS
Irrigation Regimes									
I_1: 80% ETc	15.09	21.28	25.44	28.98	14.00	20.98	24.54	27.35	28.17
I_2 : 60% ETc	15.02	21.11	25.41	28.76	13.94	20.44	23.59	26.52	27.64
I_3 : 40% ETc	12.98	19.28	24.30	27.33	13.22	19.94	22.63	24.44	25.89
SE (m)±	0.06	0.09	0.14	0.15	0.07	0.17	0.35	0.13	0.17
CD at 5%	0.25	0.36	0.54	0.59	0.29	0.66	1.38	0.51	0.56
Irrigation Intervals									
D_1: 2 days	14.83	21.00	25.56	29.17	14.93	21.65	25.11	27.57	28.37
D_2 : 3 days	14.83	20.80	25.30	28.74	13.78	20.54	23.59	26.15	27.44
D_3: 5 days	13.43	19.87	24.30	27.17	12.46	19.19	22.06	24.59	25.88
SE(m)±	0.10	0.15	0.16	0.21	0.14	0.13	0.16	0.13	0.22
CD at 5%	0.30	0.43	0.46	0.62	0.40	0.38	0.46	0.38	0.62
Interactions									
Mulch X Irrigation Regimes									
SE(m)±	0.11	0.17	0.28	0.22	0.10	0.18	0.25	0.12	0.21
CD at 5%	Sig.	Sig.	NS	NS	Sig.	NS	NS	Sig.	NS
Mulch x irrigation intervals									
SE(m)±	0.14	0.61	0.22	0.30	0.20	0.19	0.22	0.19	0.31
CD at 5%	Sig.	Sig.	NS	NS	NS	NS	NS	NS	NS
Irrigation regimes x irrigation intervals									
SE(m)±	0.18	0.26	0.28	0.37	0.24	0.23	0.27	0.23	0.38
CD at 5%	Sig.	Sig.	NS	NS	Sig.	NS	NS	NS	NS
Mulch X Irrigation Regimes X Irrigation Intervals									
SE(m)±	0.25	0.36	0.39	0.52	0.34	0.32	0.39	0.32	0.53
CD at 5%	Sig.	1.06	NS	NS	Sig.	NS	NS	NS	NS
Control									
Surface	12.33	18.22	22.67	24.78	12.00	18.44	20.56	22.11	22.94
General mean	14.36	20.56	25.05	28.36	13.72	20.46	23.59	26.10	27.23

Table 4. Interactions effect on number of internodes

Treatments	Plant cane				Ratoon cane			
	180 DAP		240 DAP		180 DAR		Harvest	
	M_1	M_O	M_1	M_O	M_1	M_O	M_1	M_O
Mulch x Irrigation regimes								
I_1:80% ETc	15.70	14.96	21.70	21.33	14.19	14.09	27.59	27.11
I_2:60% ETc	15.22	14.33	21.22	20.52	13.85	13.81	26.30	26.74
I_3:40% ETc	14.00	11.96	20.52	18.04	13.81	12.63	25.41	23.48
SE (m)±	0.11		0.17		0.10		0.12	
CD at 5%	0.43		0.65		0.41		0.47	
Mulch x Irrigation intervals								
D_1:2 days	15.56	14.59	21.67	20.85				
D_2:3 days	15.07	14.11	21.15	19.93				
D_3:5 days	14.30	12.56	20.63	19.11				
SE±	0.14		0.21					
CD at 5%	0.42		0.61					
Irrigation regimes x Irrigation intervals								
Interactions	**180 DAP**						**180 DAR**	
I_1 D_1	16.28						15.72	
I_1 D_2	16.00						15.06	
I_1 D_3	14.28						13.78	
I_2 D_1	15.39						14.06	
I_2 D_2	15.00						14.00	
I_2 D_3	13.22						12.72	
I_3 D_1	13.39						13.50	
I_3 D_2	13.11						12.50	
I_3 D_3	12.61						12.17	
SE±	0.18						0.24	
CD at 5%	0.52						0.70	
Mulch x Irrigation regimes x Irrigation intervals								
I_1 D_1			23.00	22.11				
I_1 D_2			21.67	22.00				
I_1 D_3			20.56	19.89				
I_2 D_1			21.67	21.56				
I_2 D_2			21.44	20.33				
I_2 D_3			20.33	19.56				
I_3 D_1			20.44	19.67				
I_3 D_2			20.33	18.89				
I_3 D_3			20.89	15.67				
SE±			0.36					
CD at 5%			1.06					

***DAP= Days after planting and DAR= Days after rationing**

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Table 5. Periodical length of internodes (cm) of sugarcane as influenced by various treatments.

Treatments	Plant cane				Ratoon cane				Pooled mean
	Days after planting				Days after ratooning				
	180	240	300	Harvest	180	240	300	Harvest	
Mulch									
M_1: Mulch	11.21	12.76	13.75	14.80	8.63	11.02	13.04	13.91	14.36
M_0: No-mulch	10.94	12.35	13.27	14.36	8.15	10.14	12.26	13.23	13.80
SE (m)±	0.04	0.06	0.05	0.06	0.06	0.10	0.06	0.11	0.11
CD at 5%	0.23	0.35	0.30	0.34	0.39	0.63	0.34	0.67	0.42
Irrigation regimes									
I_1: 80% ETc	11.68	13.14	14.22	15.21	9.21	11.46	13.50	14.41	14.81
I_2 : 60% ETc	11.43	13.14	14.05	15.01	8.73	10.84	12.83	13.66	14.33
I_3 : 40% ETc	10.11	11.38	12.25	13.54	7.22	9.44	11.63	12.65	13.09
SE (m)±	0.07	0.07	0.13	0.18	0.11	0.15	0.08	0.08	0.17
CD at 5%	0.26	0.26	0.51	0.72	0.42	0.58	0.30	0.32	0.57
Irrigation intervals									
D_1: 2 days	11.31	12.88	13.85	15.18	9.03	11.47	13.40	14.26	14.72
D_2 : 3 days	11.25	12.88	13.70	14.56	8.58	10.57	12.68	13.60	14.08
D_3: 5 days	10.66	11.90	12.98	14.02	7.55	9.70	11.87	12.86	13.44
SE(m)±	0.14	0.14	0.11	0.16	0.08	0.15	0.13	0.11	0.17
CD at 5%	0.40	0.40	0.33	0.47	0.24	0.44	0.39	0.33	0.48
Interactions									
Mulch x irrigation regimes									
SE(m)±	0.20	0.15	0.08	0.28	0.11	0.23	0.13	0.12	0.27
CD at 5%	NS	NS	NS	NS	Sig.	NS	NS	NS	NS
Mulch x irrigation intervals									
SE(m)±	0.20	0.20	0.16	0.23	0.12	0.21	0.19	0.16	0.24
CD at 5%	NS	NS	NS	NS	Sig.	NS	NS	NS	NS
Irrigation regimes x irrigation intervals									
SE(m)±	0.24	0.24	0.20	0.28	0.14	0.26	0.23	0.19	0.29
CD at 5%	Sig.	Sig.	Sig.	NS	Sig.	NS	NS	NS	NS
Mulch x irrigation regimes x irrigation intervals									
SE(m)±	0.34	0.34	0.28	0.39	0.20	0.37	0.33	0.28	0.41
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
Control									
Surface	8.97	10.47	12.73	13.81	8.04	10.18	12.16	13.17	13.49
General mean	11.07	12.55	13.51	14.58	8.39	10.58	12.65	13.57	14.08

Table 6. Interactions effect on length of internodes

Interactions	180 days after ratooning	
	Mulch	No-mulch
Mulch x Irrigation regimes		
I_1 : 80% ETc	9.27	9.16
I_2 : 60% ETc	8.93	8.53
I_3 : 40% ETc	7.68	6.76
SE(m)±	0.11	
CD at 5%	0.43	
Mulch x Irrigation intervals		
D_1 : 2 days	9.22	9.19
D_2 : 3 days	8.87	7.94
D_3 : 5 days	7.79	7.31
SE(m)±	0.12	
CD at 5%	0.36	

Interactions	Plant cane			Ratoon
	180 DAP	240 DAP	300 DAP	180 DAR
Irrigation regime x irrigation intervals				
I_1 D_1	11.94	13.49	14.58	9.90
I_1 D_2	11.74	13.46	14.33	9.47
I_1 D_3	11.37	12.86	14.03	8.27
I_2 D_1	11.59	13.24	14.23	9.20
I_2 D_2	11.54	13.07	14.07	8.97
I_2 D_3	10.87	12.12	12.80	8.02
I_3 D_1	11.14	12.73	13.59	8.23
I_3 D_2	10.38	11.92	12.64	7.07
I_3 D_3	9.07	10.11	11.31	6.36
SE±	0.18	0.16	0.16	0.14
CD at 5%	0.54	0.49	0.51	0.42

Table 7. Periodical girth (cm) of internodes as influenced by various treatments

Treatments	Plant cane				Ratoon cane				Pooled mean
	180 DAP	240 DAP	300 DAP	Harvest	180 DAP	240 DAP	300 DAP	Harvest	
Mulch									
Mulch	12.18	13.09	13.72	14.50	11.08	12.15	13.03	13.98	14.24
No-mulch	12.12	13.00	13.67	14.18	10.86	11.85	12.72	13.50	13.84
SE (m)±	0.05	0.05	0.03	0.08	0.060	0.059	0.052	0.096	0.11
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
Irrigation regimes									
I_1: 80% ETc	12.39	13.21	13.82	14.57	11.30	12.36	13.22	14.17	14.37
I_2 : 60% ETc	12.35	13.07	13.71	14.52	10.96	11.86	12.89	13.72	14.12
I_3 : 40% ETc	11.71	12.86	13.36	13.92	10.75	11.79	12.52	13.34	13.63
SE (m)±	0.11	0.05	0.04	0.03	0.08	0.09	0.09	0.08	0.07
CD at 5%	0.45	0.18	0.17	0.13	0.42	0.49	0.51	0.47	0.26
Irrigation intervals									
D_1: 2 days	12.49	13.24	13.98	14.70	11.54	12.76	13.62	14.43	14.56
D_2 : 3 days	12.18	13.07	13.65	14.43	10.89	11.77	12.74	13.72	14.08
D_3: 5 days	11.79	12.83	13.46	13.89	10.48	11.48	12.27	13.08	13.49
SE(m)±	0.08	0.05	0.05	0.05	0.11	0.14	0.12	0.13	0.12
CD at 5%	0.24	0.15	0.16	0.15	0.33	0.41	0.34	0.38	0.34
Interactions									
Mulch X irrigation regimes									
SE(m)±	0.07	0.09	0.09	0.04	0.170	0.220	0.176	0.186	0.166
CD at 5%	Sig.	NS	NS	Sig.	NS	NS	NS	NS	NS
Mulch X irrigation intervals									
SE(m)±	0.12	0.07	0.08	0.07	0.161	0.196	0.165	0.185	0.171
CD at 5%	Sig.	Sig.	Sig.	Sig.	NS	NS	NS	NS	NS
Irrigation regimes X irrigation intervals									
SE(m)±	0.24	0.24	0.20	0.28	0.197	0.240	0.202	0.226	0.210
CD at 5%	Sig.	Sig.	Sig.	NS	Sig.	Sig.	NS	NS	NS
Mulch X irrigation regimes X irrigation intervals									
SE(m)±	0.20	0.12	0.13	0.12	0.279	0.340	0.286	0.320	0.297
CD at 5%	Sig.	Sig.	NS	Sig.	NS	NS	NS	NS	NS
Control									
Surface	7.32	8.21	9.53	11.16	11.20	12.10	13.23	14.06	12.61
General mean	12.15	13.05	13.54	14.34	10.97	12.00	12.88	13.74	14.04

Table 8. Interactions effect on girth of internodes

Interactions	Days after planting							
	180		240		300		Harvest	
	M_1	Mo	M_1	Mo	M_1	Mo	M_1	Mo
Mulch x Irrigation regimes								
I_1:80% ETc	12.62	12.50			14.62			14.53
I_2 :60% ETc	12.27	12.08			14.61			14.42
I_3:40% ETc	11.65	11.76			14.26			13.58
SE(m)±	0.07				0.04			
CD at 5%	0.27				0.19			
Mulch x Irrigation intervals								
D_1: 2 days	12.50	12.47	13.28	13.20	14.13	13.83	14.84	14.54
D_2: 3 days	12.04	12.35	13.16	12.99	13.74	13.56	14.75	14.21
D_3 : 5 days	12.00	11.53	13.01	12.65	13.46	13.45	13.88	13.91
SE(m)±	0.12		0.07		0.08		0.08	
CD at 5%	0.34		0.21		0.32		0.34	

Irrigation regimes x Irrigation intervals

Interactions	Plant cane		Ratoon cane	
	180 DAP	Harvest	180 DAR	240 DAR
I_1D_1	12.87	15.13	12.03	13.45
I_1D_2	12.62	14.68	11.60	12.81
I_1D_3	12.39	14.52	10.95	11.42
I_2D_1	12.44	14.72	11.22	12.71
I_2D_2	12.34	14.32	10.72	11.51
I_2D_3	12.16	14.22	11.88	12.12
I_3D_1	11.58	13.91	10.66	11.37
I_3D_2	11.57	14.09	10.58	11.74
I_3D_3	11.39	13.46	10.06	11.49
SE(m)±	0.14	0.09	0.20	0.24
CD at 5%	0.41	0.25	0.58	0.70

Mulch x Irrigation regimes x Irrigation intervals							
I_1D_1	12.90	12.83	13.66	13.40		15.34	14.92
I_1D_2	12.70	12.53	13.47	13.17		15.01	14.72
I_1D_3	12.21	12.17	13.24	13.17		14.46	14.26

I_2D_1	12.61	12.39	13.27	13.06		14.74	14.34
I_2D_2	12.43	12.27	13.18	13.02		14.72	14.29
I_2D_3	12.49	12.10	13.06	12.89		14.49	13.98
I_3D_1	12.41	11.26	13.02	12.74		14.31	13.69
I_3D_2	11.93	11.21	13.03	12.68		14.38	13.51
I_3D_3	11.53	10.72	12.71	12.11		13.83	13.08
SE(m)±	0.20		0.12			0.12	
CD at 5%	0.59		0.36			0.39	

*M_1= Mulch and Mo= No-mulch

Table 9. Cane and sugar yield of sugarcane in plant and ratoon cane

Treatments	Cane yield (t ha^{-1})			Sugar yield (t ha^{-1})		
	Plant cane	Ratoon cane	Pooled mean	Plant cane	Ratoon cane	Pooled mean
Mulch						
M_1:Mulch	146.80	146.52	146.66	17.12	17.08	17.10
Mo :No-mulch	140.03	136.80	138.42	16.38	15.95	16.16
SE(m)±	2.77	1.04	2.57	0.34	0.21	0.35
CD at 5%	NS	6.32	NS	NS	NS	NS
Irrigation regimes						
I_1: 80% ETc	147.76	149.12	148.44	16.47	16.62	16.54
I_2 : 60% ETc	144.51	142.80	143.65	17.19	16.98	17.09
I_3 : 40% ETc	137.99	133.06	135.52	16.59	15.94	16.27
SE (m)±	1.76	1.51	2.01	0.24	0.18	0.26
CD at 5%	6.91	5.92	6.55	NS	0.72	NS
Irrigation intervals						
D_1: 2 days	148.45	147.26	147.85	17.07	16.92	17.00
D_2 : 3 days	147.49	143.37	145.43	17.10	16.63	16.87
D_3: 5 days	134.32	134.34	134.33	16.07	15.99	16.03
SE(m)±	2.52	1.72	2.64	0.29	0.22	0.31
CD at 5%	7.36	5.02	7.51	0.84	0.64	NS
Interactions						
Mulch x Irrigation regimes						
SE(m)±	3.69	1.79	3.55	0.54	0.30	0.54
CD at 5%	NS	NS	NS	NS	NS	NS
Mulch x Irrigation intervals						
SE(m)±	3.57	2.43	3.74	0.41	0.31	0.45
CD at 5%	NS	NS	NS	NS	NS	NS
Irrigation regimes x Irrigation intervals						
SE(m)±	4.37	2.98	4.58	0.50	0.38	0.55
CD at 5%	NS	NS	NS	NS	NS	NS
Mulch x Irrigation regimes x Irrigation intervals						
SE(m)±	6.18	4.21	6.47	0.71	0.54	0.77
CD at 5%	NS	NS	NS	NS	NS	NS
Control						
SI: Surface irrigation	119.02	118.22	118.62	11.41	12.06	11.74
General mean	**143.42**	**141.66**	**142.54**	**16.75**	**16.51**	**16.63**