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EFFECT OF SUBSURFACE DRIP IRRIGATION AND MULCHING ON PERIODICAL LEAF AREA AND DRY MATTER OF *SURU* SUGARCANE

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Abstract: An experiment was conducted at Post Graduate Research Farm of Inter Faculty Department of Irrigation Water Management, M.P.K.V., Rahuri (Maharashtra) during the year 2014-15 to study the response of *suru* sugarcane to mulch, irrigation regimes and irrigation intervals under subsurface drip irrigation (SSDI) in respect to growth attributes and yield of sugarcane. The leaf area and dry matter production plant^{-1} was significantly influenced by irrigation regimes and maximum with 80% ETc irrigation regimes. However, in most of the growth parameters it was remained at par with 60% ETc irrigation regime. Periodical leaf area, dry matter and yield of cane were increased with increased irrigation regimes from 40% ETc to 80% ETc. The values of leaf area, dry matter at all days of observations and yield of cane with 2 days irrigation interval was remained at par with 3 days irrigation interval.

Index terms : **Subsurface drip, mulching, irrigation regimes, dry matter, leaf area and sugarcane**

I. INTRODUCTION

Sugarcane is an important cash crop of India which was grown over 46.69 lakh hectares with total production of 67624 thousand ton (2017-18). It contributes 19.60% of world's total production with average productivity of 70.93 t ha^{-1}. Whereas, the state of Maharashtra the area under sugarcane was 1.07 M ha with production 95.2 MT. The Maharashtra state has established its supreme position in Indian Sugar Industry by contributing 107.9 lakh ton of total sugar production. Out of 532 sugar factories in India, 188 are operating in Maharashtra state indicates that sugarcane industry in Maharashtra is of prime importance.

Sugarcane crop requires high water and it ranges from 2000-3000 mm. In Maharashtra sugarcane crop is grown on 3% of the total cropped area which utilizes 60% of irrigation water. For production of one kilogram of sugar in Maharashtra it needs 2068 liters of water, where as in UP the requirement is almost half, i.e. 1044 liters. Due to inadequate supply of water, the heavy losses in yield may occur (Thakkar, 2013). However, at present available water source in Maharashtra is being utilized through adoption of moisture conservation practices like mulching and advanced irrigation practices.

Among the advanced irrigation methods, the method like subsurface drip offers many advantages over surface drip irrigation such as; reduced evaporation loss and precise placement and management of water and nutrient leading to more efficient water use, greater water application uniformity, enhanced growth, crop yield and quality (Camp *et al*., 1997).

Mulches decrease soil water evaporation, results in a more uniform soil moisture content and reduce the requirement of irrigation water. It avoids the fluctuations in temperature in the first 20–30 cm depth of soils, promotes root development, faster crop development and earlier harvest (Sajid *et al.*, 2013). About 8-10 tonnes of sugarcane trash can be obtained per hectare which is equal to 65 Kg of urea, 67.5 Kg of single superphosphate and 330 Kg of muriate of potash (Girijesh and Chandrasehar, 2001).

The present study was undertaken to study the influence of growth parameters like leaf area, dry matter production etc. and yield by adopting advanced irrigation methods like surface and subsurface drip irrigation.

II. RESEARCH METHODOLOGY

The experiment was designed in strip-split plot comprised of two main plot treatments (Sugarcane trash mulch and no mulch), three sub-plot treatments as 80%, 60% and 40% ETc irrigation regimes and three sub-sub plot treatments of irrigation intervals at 2, 3 and 5 days. The surface drip and surface irrigation method taken as control treatments during the year 2014-2015. The paired row planting of single eye bud sets of sugarcane (*Cv*.CoM 0265) was planted at 60-120 x 60 cm in February, 2014 under subsurface drip irrigation method in such way that lateral was buried at 20 cm depth from ground surface and sugarcane planting at 5 cm depth below subsurface drip.

The recommended fertilizer dose for *suru* cane was applied @ 200:92:92 kg ha^{-1} in 13 splits at 15 days interval through surface drip and subsurface drip as recommended by MPKV, Rahuri. In surface irrigation treatment, the recommended dose of fertilizer as 250:115:115 kg N, P_2O_5 and K_2O ha^{-1} was applied of which 50% of phosphorous and potash was applied at the time of planting and remaining at 16 weeks after planting. The nitrogen was given in four splits as 10% at planting, 40% after 4 weeks, 10% after 12 weeks and remaining 40% at 16 weeks after planting i.e at final earthing up. The sugarcane trash mulch is preferred as mulching material and applied 6 weeks after planting of crop @ 5 t ha^{-1} in 10 cm thickness between the paired rows of cane. The pan evaporation of 2, 3 and 5 days was cumulated to estimate the water quantity for 2, 3 and 5 days interval, respectively. The amount of irrigation water was estimated by climatological approach formula given in FAO paper No.16. The irrigations for control treatment of surface drip were applied at alternate days at 100% ETc and that of surface irrigation at 75 mm CPE.

The leaf area was measured at bi-monthly intervals from 120 days up to harvest and was estimated by using formula given by Venkataraman and Ramanujan (1999).

$$\mathbf{A} = \sum(\mathbf{L} * \mathbf{B})\ \mathbf{K} \qquad (1)$$

Where,
A = Leaf area per plant (cm^2) , L = Maximum length of leaf (cm)
B = Maximum width of leaf (cm), K = Constant, 0.75
$\sum$ = Summation for all leaves.

For dry matter studies, the plants were taken at 90 days interval after planting. The whole plants were chopped into small pieces and sun dried as well as oven dried at 65°C until the constant weight was obtained and was expressed in grams. All the canes from treatment plots were harvested separately, detrashed and yield was recorded at harvest.

III. RESULTS AND DISCUSSIONS:

The leaf area, dry matter per plant and yield were influenced due to mulch, irrigation regimes and irrigation intervals. Results of present investigations are enumerated in Table 1, Table 2 Table 3 and Table 4.

1. Leaf area per plant: The mean leaf area was significantly increased from 212.9 to 564.2 cm^2 from 120 day onwards till 300 days and at harvest, it was 528.5 cm^2.

Effect of mulch: The leaf area was significantly increased linearly from 120 DAP to 300 DAP (288.7 to 752.2 cm^2 $plant^{-1}$) thereafter at harvest, it was decreased due to leaf senescence because of old age in mulch treatment. Highest soil moisture values were recorded with mulches due to decreased evaporation and ultimately mulches shows positive effect on increasing cane vegetative growth (Yaghi *et al*., 2013).

Effect of irrigation regimes: The significantly maximum leaf area per plant was observed with 80% ETc irrigation regime but remained at par with 60% ETc irrigation regime at all the days of observations except at 180 DAP. It may be due to the reduction in leaf size and leaf curling results in reduced leaf area under water stress condition (Rao *et al.*, 2000).

Effect of irrigation intervals: The 2 days irrigation interval indicated significantly highest leaf area per plant. However, it was remained at par with 3 days irrigation interval at all the days of observations except at 180 and 240 DAP.

Effect of interactions

Mulch x Irrigation regimes: The 60% ETc irrigation regime with mulch was at par with that of 80% ETc irrigation regime at 120 and 180 DAP (Table 1a).

Mulch x Irrigation intervals: Significantly highest leaf area was observed in 2 days irrigation interval with mulch at 120 and 180 DAP followed by and remained at par with 3 days irrigation interval with mulch at 120 DAP only.

Irrigation regimes x Irrigation intervals : Only at 180 and 240 DAP, the interaction between irrigation regimes and irrigation intervals was significant. The combination of 80% ETc and 2 days irrigation interval registered significantly higher leaf area 417.2 cm^2 and 725.1 cm^2at 180 and 240 DAP, respectively; however it was at par with 80% ETc irrigation regime + 3 days irrigation interval at 180 DAP (401.7 cm^2). The lower leaf area was observed in 40% ETc and 5 days irrigation intervals combination (201.0 cm^2).

Mulch x Irrigation regimes x Irrigation intervals: The leaf area was significantly differed due to interaction among mulch, irrigation regimes and irrigation intervals at 180 DAP. The 80% ETc irrigation regime and 2 days irrigation interval with trash mulch ($M_1I_1D_1$) registered significantly higher leaf area (484.6 cm^2) followed by and remained at par with 80% ETc and 3 days irrigation interval with mulch ($M_1I_1D_2$) i.e. 472.9 cm^2.

2. Dry matter per plant

Effect of mulch : The significantly highest dry matter per plant was resulted in mulch treatment as 86.69, 243.24, 314.20 and 414.31 g $plant^{-1}$ at 90, 180, 270 days and at harvest, respectively than no-mulch. In no-mulch treatment it was increased from 78.63 g to 398.16 g (Table 3). These results are in conformity with Gurusamy *et al.*, (2011) in which they mentioned that increased P and K uptake rates, which in turn facilitated the higher dry matter production in SSDI relative to surface drip irrigation. The SSDI attributes to optimized parameters such as moisture movement, nutrient mobility, availability and uptake of applied nutrients due to higher soil moisture content, prevention of losses such as leaching, volatilization and denitrification. Due to the improved plant-water-nutrient status under subsurface drip fertigation system, all the plant growth and yield characters viz., dry matter production, number of millable cane and cane weight are affected significantly

Effect of irrigation regimes: The highest dry matter per plant was increased from 90 days to harvest. It was significantly higher in 80% ETc irrigation regime at 90 DAP. However, it was remained at par with 60% ETc irrigation regime. Less dry matter was observed in 40% ETc irrigation regime. The reductions in shoot or leaf dry weights under high moisture deficit may be due to lateral root elongation which decreases shoot to root ratio (Salahaddin *et al.*, 2013).

Effect of irrigation intervals: The 2 days irrigation interval at all the days of observation showed significantly highest dry matter per plant. The total plant biomass increased with reducing the irrigation interval due to more nutrients uptake and higher photosynthetic rates (Adeoye *et al*., 2014).

Effect of interactions

Mulch x Irrigation regimes: It is revealed from Table 4 that the interaction effect between mulch and irrigation regimes was significant at harvest. The significantly maximum dry matter per plant was obtained by 80% ETc irrigation regime with mulch (425.50 g).

Mulch x Irrigation intervals: The significant interactions between mulch and irrigation interval was observed at 180, 270 DAP and at harvest. Combination of the 2 days irrigation interval and mulch recorded more dry matter per plant (260.95, 331.11 and 435.54 g) than other combinations at 180, 270 DAP and at harvest of plant cane, respectively. Only at 180 days, 3 days irrigation interval with mulch (258.08 g) was at par with 2 days irrigation interval with mulch.

Irrigation regimes x Irrigation intervals: At all these stages, maximum dry matter (g $plant^{-1}$) was observed in 80% ETc irrigation regime with 2 days irrigation interval (I_1D_1) which was remained at par with 60% ETc irrigation regime + 3 days (I_1D_2) at 180 DAP and at harvest.

Mulch x Irrigation regimes x Irrigation intervals : In all the combinations, 80% ETc irrigation regime and 2 days irrigation interval with mulch ($M_1I_1D_1$) recorded significantly highest dry matter (271.35 g) at 180 DAP and at harvest. However, it was remained at par with 80% ETc irrigation regime + 3 days irrigation interval at 180 DAP (266.99 g).

3. Yield: The data pertaining to the cane yield is presented in Table 3.

Effect of mulch: The non-significantly higher cane yield was observed under mulch treatment and it was 3.09 % less than surface drip irrigation method (151.49 t ha^{-1}). It was due to water applied at 100% ETc with alternate days in surface drip irrigation method. Under subsurface drip irrigation lodging of cane was observed at 240 DAP. Lodging might be due to reasons like conserved moisture in root zone leads to vigorous plant cane height in cultivar like CoM-0265, no earthing-up especially in SSDI treatments, heavy rainfall (84.2 and 106.8 mm) in 42nd meteorological week accompanied with high winds. Similar results are observed by Aslam *et al.*, (2008).

Effect of irrigation regimes: Significantly highest cane yield was observed in 80% ETc irrigation regimes however; it was remained at par with 60% ETc irrigation regime. The yield under surface drip (SDI) was slightly better than subsurface drip (SSDI) with 80% ETc irrigation water.

Effect of irrigation intervals: The sugarcane yield was significantly increased in 2 days irrigation interval and was remained at par in 3 days irrigation interval.

Effect of interactions: The interaction effects i.e. mulch x irrigation regimes, mulch x irrigation intervals, irrigation regimes x irrigation intervals and mulch x irrigation regimes x irrigation intervals were found non-significant**.**

IV.CONCLUSION: Based on the results obtained it could be concluded that, the growth parameters significantly influenced and yield were improved under Sub Surface Drip Irrigation (SSDI) with mulch. The 80% ETc irrigation regimes shows significantly maximum growth attributes and yield which was at par with that of 60% ETc irrigation regime. Similar results were obtained with 3 and 2 days irrigation intervals, respectively.

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Table 1: Periodical leaf area per plant (cm^2) of *suru* sugarcane as influenced by different treatments

Treatments	Days after planting (DAP)				
	120	180	240	300	Harvest
Mulch					
M_1 : Mulch	288.7	350.7	624.1	752.2	658.5
Mo : No mulch	215.7	276.2	590.6	636.7	548.7
SE(m)±	1.08	8.00	4.26	9.90	8.83
CD at 5%	5.91	48.72	25.32	60.21	53.61
Irrigation regimes					
I_1: 80% ETc	285.3	362.2	661.8	742.8	666.4
I_2: 60% ETc	275.4	332.4	623.4	739.5	633.8
I_3: 40% ETc	195.9	245.8	536.7	601.1	510.5
SE (m)±	6.32	5.79	10.42	23.23	11.70
CD at 5%	24.61	22.60	40.81	90.90	46.13
Irrigation Intervals					
D_1: 2 days	281.4	367.6	642.6	738.1	644.0
D_2: 3 days	264.0	332.4	609.3	716.1	616.5
D_3: 5 days	211.2	240.4	570.1	629.1	550.2
SE(m)±	8.63	7.51	7.53	15.11	12.74
CD at 5%	25.12	22.98	22.04	44.01	37.10
Interactions					
Mulch x Irrigation regimes					
SE(m)±	9.30	11.20	9.51	23.50	24.21
CD at 5%	Sig.	Sig.	NS	NS	NS
Mulch x Irrigation intervals					
SE(m)±	12.21	10.63	10.61	21.30	18.01
CD at 5%	Sig.	Sig.	NS	NS	NS
Irrigation regimes x Irrigation intervals					
SE(m)±	14.91	13.01	13.01	26.11	22.01
CD at 5%	NS	Sig.	Sig.	NS	NS
Mulch x Irrigation regimes x Irrigation intervals					

SE(m)+	21.11	18.42	18.40	36.91	31.21
CD at 5%	NS	Sig.	NS	NS	NS
Control					
SDI: Surface drip irrigation	207.4	324.5	619.9	682.1	634.6
SI: Surface irrigation	252.2	313.5	607.3	694.4	603.6
General mean	**212.9**	**271.8**	**542.7**	**564.2**	**528.5**

Table 2: Interaction effects of leaf area (cm^2) on *suru* sugarcane

Interactions	120 DAP		180 DAP	
	Mulch	No-Mulch	Mulch	No-Mulch
Mulch x Irrigation regimes				
I_1: 80% ETc	338.8	231.8	410.9	313.5
I_2: 60% ETc	324.6	226.3	386.1	278.6
I_3: 40% ETc	202.6	189.1	255.0	236.5
SE (m)+	9.30		11.20	
CD at 5%	36.54		44.12	
Mulch x Irrigation intervals				
D_1: 2 days	326.3	236.4	422.7	312.5
D_2: 3 days	314.2	213.8	376.1	288.8
D_3: 5 days	225.5	197.0	253.3	227.4
SE (m)+	12.21		10.63	
CD at 5%	35.53		31.10	
Irrigation regimes x Irrigation intervals				
	180 DAP		**240 DAP**	
I_1 D_1	417.2		725.1	
I_1 D_2	401.7		655.6	
I_1 D_3	300.3		604.8	
I_2 D_1	385.2		654.1	
I_2 D_2	359.6		636.0	
I_2 D_3	252.3		580.2	
I_3 D_1	267.8		548.5	
I_3 D_2	236.0		536.4	
I_3 D_3	201.0		525.3	
SE (m)+	13.01		12.21	
CD at 5%	38.12		36.19	
Mulch x Irrigation regimes x Irrigation intervals				
I_1 D_1			484.6	349.8
I_1 D_2			472.9	336.1
I_1 D_3			310.5	290.2
I_2 D_1			467.3	297.4
I_2 D_2			424.1	295.1
I_2 D_3			261.4	243.3
I_3 D_1			280.8	254.7
I_3 D_2			236.9	235.0
I_3 D_3			217.6	184.3
SE (m)+			18.40	
CD at 5%			53.81	

Table 3: Periodical dry matter per plant (g) and cane yield (t ha^{-1}) of *suru* sugarcane as influenced by different treatments

Treatments	Days after planting (DAP)				Cane yield t ha^{-1}
	90	180	270	Harvest	
Mulch					
M_1 : Mulch	86.69	243.24	314.20	414.31	146.80
Mo : No mulch	78.63	208.81	285.05	398.16	140.03
SE(m)+	0.77	1.50	1.76	1.47	2.77
CD at 5%	4.66	9.15	10.74	8.94	NS
Irrigation regimes					
I_1: 80% ETc	86.40	236.91	314.15	419.19	147.76
I_2: 60% ETc	83.84	228.01	301.92	411.03	144.51
I_3: 40% ETc	77.74	213.16	282.79	388.49	137.99
SE (m)+	1.10	1.09	1.03	0.70	1.76
CD at 5%	4.33	4.27	4.05	2.76	6.91
Irrigation intervals					
D_1: 2 days	89.79	247.26	319.79	424.17	147.76
D_2: 3 days	82.18	234.12	305.18	419.39	144.51
D_3: 5 days	76.02	196.70	273.90	375.15	137.99
SE (m)+	0.94	0.80	0.85	1.12	1.76
CD at 5%	2.73	2.35	2.48	3.27	6.91
Interactions					
Mulch x Irrigation regimes					
SE (m)+	1.04	1.28	2.31	0.63	3.69
CD at 5%	NS	NS	NS	Sig.	NS
Mulch x Irrigation intervals					
SE (m)+	1.32	1.14	1.20	1.58	3.57
CD at 5%	NS	Sig.	Sig.	Sig.	NS
Irrigation regimes x Irrigation intervals					
SE (m)+	1.62	1.39	1.47	1.94	4.37
CD at 5%	NS	Sig.	Sig.	Sig.	NS
Mulch x Irrigation regimes x Irrigation intervals					
SE (m)+	2.29	1.97	2.09	2.74	6.18
CD at 5%	NS	Sig.	NS	Sig.	NS
Control					
SDI: Surface drip irrigation	92.28	234.52	309.12	402.35	151.49
SI: Surface irrigation	72.66	190.63	265.23	363.21	119.02
General mean	**82.66**	**226.03**	**299.62**	**406.24**	**143.42**

Table 4: Interaction effects of dry matter per plant (g) on *suru* sugarcane

Treatments	Days after planting (DAP)					
	180		270		Harvest	
	Mulch	No-mulch	Mulch	No-mulch	Mulch	No-mulch
Mulch x Irrigation regimes						
I_1: 80% ETc					425.50	412.87
I_2: 60% ETc					420.35	401.70
I_3: 40% ETc					397.08	379.90
SE (m)±					0.63	
CD at 5%					2.48	
Mulch x Irrigation intervals						
D_1: 2 days	260.95	233.57	331.11	308.47	435.54	412.79
D_2: 3 days	258.08	210.16	323.50	286.86	427.93	410.84
D_3: 5 days	210.69	182.70	287.99	259.80	379.46	370.85
SE (m)±	1.14		1.20		1.58	
CD at 5%	3.32		3.51		4.62	
Irrigation regimes x Irrigation intervals						
Interactions	**180 DAP**		**270 DAP**		**Harvest**	
I_1 D_1	261.77		339.85		442.03	
I_1 D_2	250.88		325.63		430.79	
I_1 D_3	229.14		293.89		401.01	
I_2 D_1	243.12		319.57		429.51	
I_2 D_2	234.50		304.28		426.36	
I_2 D_3	205.83		283.03		384.74	
I_3 D_1	224.74		291.69		400.96	
I_3 D_2	198.67		275.87		377.21	
I_3 D_3	185.59		262.79		363.51	
SE (m)±	1.39		4.47		4.94	
CD at 5%	4.07		13.30		15.66	
Mulch x Irrigation regimes x Irrigation intervals						
I_1 D_1	271.35	252.19			451.90	432.17
I_1 D_2	266.99	241.71			441.71	427.93
I_1 D_3	251.46	206.82			413.40	388.90
I_2 D_1	260.04	219.25			436.75	417.31
I_2 D_2	258.58	210.41			433.66	415.97
I_2 D_3	222.14	189.52			390.96	378.52
I_3 D_1	248.66	200.83			413.02	388.62
I_3 D_2	212.53	184.80			382.59	371.83
I_3 D_3	197.38	173.80			364.83	362.19
SE (m)±	1.97				2.74	
CD at 5%	5.75				8.01	