International Journal of Agricultural Sciences
Volume 13 | Issue 2 | June, 2017 | 315-320 ■ e ISSN-0976-5670
DOI:10.15740/HAS/IJAS/13.2/315-320
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RESEARCH PAPER

Influence of subsurface drip fertigation duration and levels on growth parameters of plant and ratoon sugarcane

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Abstract : The simultaneous delivery of water and fertilizers to the active root zone through subsurface drip fertigation system ensures optimum growth of sugarcane. Field experiment was conducted at ZARS, V.C. Farm, Mandya during 2014-15 and 2015-16 seasons comprising of plant and ratoon cane, respectively. The investigation was conducted to know the performance of sugarcane as influenced by duration and levels of subsurface drip fertigation. Results revealed that fertigation duration upto 9.5 months recorded significantly higher growth parameters of plant and ratoon cane at harvest *viz.*, plant height (330.6 and 296.2 cm), number of tillers m^{-1} (34.66 and 43.33), leaf area $dm^2 m^{-1}$ (87.32 and 118.69), total dry matter production g $plant^{-1}$ (652.57 and 466.91) and SPAD reading (34.67 and 37.72), respectively. Growth parameters significantly not influenced by fertigation levels. Whereas, the interaction between fertigation duration and levels were significant. Fertigation upto 9.5 months with 125 per cent RDF recorded significantly higher growth parameters *viz.*, plant height (332.5 and 299.5 cm), number of tillers m^{-1} (34.97 and 43.98), leaf area $dm^2 m^{-1}$ (89.27 and 121.63), total dry matter production g $plant^{-1}$ (658.70 and 473.37) and SPAD reading (34.92 and 37.82) in plant and ratoon cane, respectively at harvest. Stastically, at par results were observed with fertigation upto 9.5 months with 100 per cent of RDF and fertigation upto 9.5 months with 75 per cent of RDF. Normal method of sugarcane cultivation with surface irrigation with 100 per cent RDF soil application recorded lower plant height (281.4 and 259.1 cm), number of tillers m^{-1} (29.2 and 38.15), leaf area $dm^2 m^{-1}$ (57.34 and 84.38), total dry matter production g $plant^{-1}$ (519.69 and 340.36) and SPAD reading (23.39 and 26.47). Thus, results clearly indicated that 25 per cent of the recommended dose of fertilizer could be saved with higher cane growth through sub surface drip fertigation (SSDF) over normal practice of sugarcane cultivation.

Key Words : Sub surface drip fertigation, Fertigation duration, Fertigation levels, SPAD reading

View Point Article : Padmanabhan, M., Nagaraju, Mohanraju, B. and Thimmegowda, M.N. (2017). Influence of subsurface drip fertigation duration and levels on growth parameters of plant and ratoon sugarcane. *Internat. J. agric. Sci.*, **13** (2) : 315-320, **DOI:10.15740/HAS/IJAS/13.2/315-320.**

Article History : **Received :** 21.03.2017; **Revised :** 24.04.2017; **Accepted :** 08.05.2017

INTRODUCTION

Fertilizers are normally applied in dry solid form during the early stages of crop development and watered by the next irrigation cycle. However, without appropriate recommendations there is the potential for nutrient

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wastage, particularly through leaching and denitrification (Thorburn *et al.*, 1998 and Dart *et al.*, 2000) associated with poor timing and excessive application of fertilizers. Plant nutrient like N, P and K are the most critical factors, which seriously limit the growth of crops. Nitrogen fertilizer is costly input and every effort needs to be made to improve the utilization of applied nitrogen by a crop. Apart from source of nitrogen, the method and time of application are important deciding factors for increasing its efficiency. Applying fertilizers directly to crop root zone through SSDF is thus an answer for judicious use of precious commodity such as water and fertilizer. The advantages of SSDF in principle have been well documented (Hutmacher *et al.*, 1993 and Haynes, 1985). The main benefit is considered to be the simultaneous delivery of water and fertilizers to the crop through subsurface drip irrigation system ensures that plant nutrients are directed to the active root zone. This facilitates accurate and flexible fertigation of soluble fertilizers through the irrigation system according to the requirements of the crop. This cannot be achieved with conventional irrigation systems. Therefore, the present study was undertaken to find out the effects of SSDI on growth of sugarcane.

MATERIAL AND METHODS

The experiment was conducted at ZARS, VC, Farm Mandya and was carried out for two seasons in plant and ratoon cane during 2014-15 and 2015-16, respectively. Experiment was laid out in Factorial Randomized Complete Block Design, replicated thrice consisting of two factors Factor A fertigation duration upto 3.5, 5.0, 6.5, 8.0 and 9.5 months and Factor B fertigation levels of 75, 100 and 125 per cent RDF with control soil application of 100 per cent RDF with surface irrigation. Recommended FYM (10 t ha^{-1}) was applied one week before planting of sets. Out of the recommended dose of fertilizer (250: 100: 125 kg NPK ha^{-1}), 50 per cent P was applied as basal dose and remaining P was applied at 105 days after planting (DAP) while earthing up for drip irrigated plots wherein, entire dose of N and K was applied through subsurface drip fertigation at different intervals of 3.5, 5.0, 6.5, 8.0 and 9.5 months with three fertigation levels of 75, 100 and 125 per cent RDF consisting 28, 40, 52, 64 and 76 splits of fertigation, respectively, twice in a week and drip irrigation was scheduled for every two days. Soil application of recommended dose of fertilizer (250: 100: 125 kg of NPK ha^{-1}) as per package of practice surface irrigation was considered as control plot. Viable and healthy two budded sugarcane sets were planted in a zig-zag manner in paired row method of planting with spacing of (165 + 30) × 30 cm. Co-86032 variety was used for planting. Earthing up was carried out by tractor drawn implement. Healthy plant population was maintained by following plant protection measures and recommended package of practices. In each plot five plants were selected randomly and tagged for recording growth observations as per standard procedures. The data were statistically analyzed by following the method of Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Drip fertigation upto 9.5 months recorded significantly higher plant height at harvest (330.6 and 296.2 cm) in plant and ratoon cane as compared to other drip fertigation treatments upto 3.5, 5.0 and 6.5 months except drip fertigation upto 8 months (321.0 and 291.0 cm) which recorded at par with drip fertigation upto 9.5 months (Table 1). Sub surface drip fertigation level did not influence significantly on plant height irrespective of growth stages. The interaction effect of drip fertigation duration and fertigation levels showed significant difference at early and later stages of crop growth both in plant and ratoon cane. At harvest significant differences in plant height was observed with drip fertigation duration upto 9.5 months with application of 125 per cent RDF through drip fertigation (332.5 and 299.5 cm). This was statistically on par with drip fertigation upto 9.5 months with 100 per cent RDF (331.6 and 295.4) and with 75 per cent RDF (327.7 and 293.7). However, lower plant height at harvest was recorded with surface furrow flood irrigation with application of 100 per cent RDF (281.4 and 259.1 cm).

Higher plant height observed under sugarcane with subsurface drip fertigation might be due to continuous availability of required moisture nearer the crop root zone, which might have resulted in higher nutrient uptake resulting in greater cell division and elongation. It is well known fact that under reduced moisture condition all the growth factors are affected adversely to greater extent under conventional irrigation method *i.e.* surface irrigation with RDF through soil application. Similar results were also reported by Aujla *et al.* (2005) who reported that higher plant height was mainly due to readily availability of nutrients to plants at right stage of crop growth led to formation of two to four joints per month since higher nutrient requirement was needed for the metabolism of differentiation of newly formed cells in the elongation process to take place in subsequent stages. The above results are in conformity with the findings of Shanmugam *et al*. (2007) who also reported that plant height was increased with drip fertigation of 125 per cent of recommended dose of fertilizer as compared to surface irrigation.

Drip fertigation upto 9.5 months recorded significantly higher number of tillers m^{-1} at harvest (34.66 and 43.33) as compared to other drip fertigation treatments upto 3.5, 5.0 and 6.5 months except drip fertigation upto 8 months which recorded (34.21 and 42.77) and was at par with drip fertigation upto 9.5 months. Drip fertigation level did not influence

Table 1 : Effect of subsurface drip fertigation duration and levels on growth parameters of plant and ratoon cane at harvest

Treatments	Plant height (cm)		No. of tillers (m^{-1})		Leaf area (dm^2 m^{-1})	
	Plant cane	Ratoon cane	Plant cane	Ratoon cane	Plant cane	Ratoon cane
Fertigation duration (D)						
D_1	296.2	273.4	33.34	41.52	68.09	94.60
D_2	304.9	279.6	33.71	41.90	72.78	99.88
D_3	313.0	285.4	33.98	42.30	77.38	105.82
D_4	321.0	291.0	34.21	42.77	81.55	111.64
D_5	330.6	296.2	34.66	43.33	87.32	118.69
S.E. ±	7.54	5.20	0.36	0.57	4.38	3.36
C.D. (P=0.05)	21.78	15.03	1.04	1.65	12.65	9.70
Fertigation levels (L)						
L_1	310.1	283.1	33.82	42.14	75.48	104.13
L_2	313.0	284.8	33.98	42.32	77.66	105.86
L_3	316.3	287.5	34.14	42.63	79.13	108.39
S.E.±	5.84	4.03	0.28	0.44	3.39	2.60
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Interaction (D×L)						
D_1L_1	292.7	270.7	33.00	41.11	65.96	93.16
D_1L_2	296.0	273.6	33.47	41.66	68.04	94.20
D_1L_3	300.0	276.0	33.54	41.79	70.25	96.45
D_2L_1	302.5	278.4	33.60	41.83	71.33	97.86
D_2L_2	304.1	279.2	33.72	41.91	72.59	99.12
D_2L_3	308.2	281.2	33.82	41.96	74.41	102.67
D_3L_1	310.1	282.8	33.90	42.15	75.86	104.26
D_3L_2	313.3	285.7	33.97	42.24	77.70	105.23
D_3L_3	315.6	287.8	34.07	42.52	78.58	107.97
D_4L_1	317.7	289.9	34.12	42.65	79.29	109.78
D_4L_2	320.1	290.2	34.21	42.77	82.23	111.89
D_4L_3	325.2	292.9	34.32	42.89	83.14	113.25
D_5L_1	327.7	293.7	34.47	42.95	84.97	115.59
D_5L_2	331.6	295.4	34.55	43.05	87.71	118.86
D_5L_3	332.5	299.5	34.97	43.98	89.27	121.63
Control	281.4	259.1	29.20	38.15	57.34	84.38
S.E.±	13.06	9.13	0.62	0.99	7.59	5.82
C.D. (P=0.05)	37.73	26.37	1.80	2.86	21.91	16.81

Note:

Factor A:	Factor B:
Fertigation duration	Fertigation levels
D_1: Fertigation upto 3.5 months	L_1: 75 % RDF
D_2: Fertigation upto 5.0 months	L_2: 100 % RDF
D_3: Fertigation upto 6.5 months	L_3: 125 % RDF
D_4: Fertigation upto 8.0 months	Control: Soil application of 100 % RDF with surface irrigation.
D_5: Fertigation upto 9.5 months	(RDF-250:100:125 NPK kg ha^{-1})
DAP-Days after planting/Ratoon initiation	NS=Non-significant

significantly on the number of tillers m^{-1} irrespective of growth stages. Drip fertigation duration and fertigation levels showed significant difference at early and later stages of crop growth both in plant and ratoon cane. At harvest significant difference in number of tillers m^{-1} was observed with drip fertigation duration upto 9.5 months with 125 per cent RDF through drip fertigation (34.97 and 43.98). This was on par with drip fertigation upto 9.5 months with 100 per cent RDF (34.55 and 43.05) and with 75 per cent RDF (34.47 and 42.95). Lower number of tillers m^{-1} was recorded at harvest in surface irrigation with application of 100 per cent RDF (29.20 and 38.15).Generally, tillering was high in all the subsurface drip feritgation treatments compared to surface irrigation method. This was mainly due to early vigorous growth of cane with the availability of required quantity of water and nutrients at the early stages compared to soil application of fertilizers where in the fluctuation in nutrient availability is very wide (Chandrashekar, 2009). Favourable moisture availability under subsurface drip fertigation enhanced the nutrient uptake and favoured for good tiller production (Nadagouda, 2011).

Leaf area, drip fertigation upto 9.5 months recorded significantly higher leaf area dm^2 m^{-1} at harvest (78.80 and 96.95) as compared to other drip fertigation treatments upto 3.5, 5.0 and 6.5 months except drip fertigation upto 8 months recorded leaf area dm^2 (73.86 and 90.92) which was at par with drip fertigation upto 9.5 months. Leaf area did not differ significantly due to fertigation levels irrespective of growth stages. Significant difference was observed with drip fertigation duration and fertigation levels. Significant differences in leaf area was observed with drip fertigation duration upto 9.5 months with 125 per cent RDF through drip fertigation in plant and ratoon cane (79.71 and 98.97 dm^2) at harvest. This was at par with drip fertigation upto 9.5 months with 100 per cent RDF (78.92 and 97.31) and 75 per cent RDF (77.76 and 94.57 dm^2). Statistically lower leaf area at harvest was recorded irrespective of growth stages with conventional irrigation with application of 100 per cent RDF in plant and ratoon cane (48.34 and 64.30 dm^2). The photosynthetic activity of plant largely depends upon leaf area. In subsurface drip fertigation required availability of water and nutrients matching with the crop demand helped the photosynthetic area to develop and remain active for longer period and was responsible for overall growth of plant. Geethalakshmi and Suresh (2011) reported that subsurface drip fertigation recorded higher plant height which helped for better utilization of solar radiation resulting in higher leaf area.

Significantly, higher total dry matter production g $plant^{-1}$ was recorded with drip fertigation upto 9.5 months at harvest (652.57 and 466.91) as compared to other drip fertigation treatments upto 3.5, 5.0 and 6.5 months except drip fertigation upto 8 months (631.85 and 448.96) (Table 2) which was at par with drip fertigation upto 9.5 months. Total dry matter production did not differ significantly due to fertigation levels irrespective of growth stages. Significant difference was observed with the interaction effect of drip fertigation duration and fertigation levels. Significantly higher total dry matter production was observed at drip fertigation duration upto 9.5 months with 125 per cent RDF through drip fertigation (658.70 and 473.37) at harvest in plant and ratoon cane. Which was at par with drip fertigation upto 9.5 months with 100 per cent RDF in plant and ratoon cane (652.54 and 466.88) and with 75 per cent RDF (646.48 and 460.48) in plant and ratoon cane. Significantly, lower total dry matter production was recorded at harvest in plant and ratoon cane (519.69 and 340.36). Higher DMP was mainly due to increased performance of plant characters such as plant height, tiller number, growth and physiological parameters. This favourable increase in plant characters was mainly due to higher soil moisture facilitated through subsurface drip irrigation which would have supplied the adequate quantity of water needed for the crop growth. This in turn led to increased photosynthesis resulting in higher dry matter production. Similar findings of higher DMP with increasing duration of fertigation was reported by Mahendran *et al*. (2005). This might be due to increased availability and uptake of water soluble nutrients from water soluble fertilizers. This favourable increase in plant characteristics was mainly due to the enhanced availability of nutrients by the continuous and split supply of nutrients along with the required quantity of water needed for the crop growth stages in sugarcane (Mahesh, 2009).

Significant difference was observed with fertigation duration and fertigation levels in SPAD reading. Significantly higher SPAD reading was observed with drip fertigation upto 9.5 months in plant and ratoon cane at 240 DAP (34.67 and 37.72). However, drip fertigation upto 8.0 months recorded at par results at 240 DAP (33.10 and 35.87). Drip fertigation level did not influence the SPAD readings irrespective of growth stages.

Interaction effect, drip fertigation upto 9.5 months with 125 per cent RDF recorded significantly higher SPAD reading in plant and ratoon cane at 240 DAP (34.92 and 37.82). However, at par results was observed with drip fertigation upto 9.5 months with 100 per cent RDF (34.62 and 37.69) and with 75 per cent RDF (34.47 and 37.64). Surface irrigation with soil application of 100 per cent RDF recorded significantly lower SPAD reading at 240 DAP (23.39 and 26.47). Aruna *et al.* (2007) observed that SPAD chlorophyll meter reading recorded at middle lamina of the third leaf from the top of millable cane registered higher SPAD reading and was mainly due to better availability of nutrients and water throughout the crop period through subsurface drip irrigation.

Soil application of 100 per cent RDF with surface irrigation recorded significantly lower growth parameters like plant height, number of tillers m^{-1}, leaf area, total dry matter production and SPAD readings. This was mainly

Table 2: Effect of subsurface drip fertigation duration and levels on growth parameters of plant and ratoon cane at harvest

Treatments	Total dry matter production (g plant^{-1})		SPAD reading At 240 DAP	
	Plant cane	Ratoon cane	Plant cane	Ratoon cane
Fertigation duration (D)				
D_1	580.75	397.20	27.21	29.98
D_2	596.71	415.68	28.74	31.29
D_3	614.15	433.15	30.34	32.85
D_4	631.85	448.96	33.10	35.87
D_5	652.57	466.91	34.67	37.72
S.E. ±	15.93	10.51	1.19	1.15
C.D. (P=0.05)	46.00	30.35	3.44	3.31
Fertigation levels (L)				
L_1	609.19	426.59	30.06	32.83
L_2	615.23	432.63	30.97	33.49
L_3	621.20	437.92	31.41	34.31
S.E.±	12.34	8.14	0.92	0.89
C.D. (P=0.05)	NS	NS	NS	NS
Interaction (D×L)				
D_1L_1	573.41	391.75	26.56	29.08
D_1L_2	580.25	397.25	27.38	30.07
D_1L_3	588.59	402.59	27.71	30.80
D_2L_1	591.93	409.93	27.93	31.11
D_2L_2	597.56	416.89	28.99	31.27
D_2L_3	600.63	420.22	29.30	31.50
D_3L_1	607.89	425.89	29.61	31.65
D_3L_2	614.56	433.56	30.52	32.92
D_3L_3	620.01	440.01	30.88	33.96
D_4L_1	626.26	444.92	31.73	34.66
D_4L_2	631.22	448.56	33.33	35.49
D_4L_3	638.07	453.40	34.24	37.45
D_5L_1	646.48	460.48	34.47	37.64
D_5L_2	652.54	466.88	34.62	37.69
D_5L_3	658.70	473.37	34.92	37.82
Control	519.69	340.36	23.39	26.47
S.E. ±	27.59	18.20	2.07	1.99
C.D. (P=0.05)	79.68	52.56	5.97	5.73

Note:

Factor A:	Factor B:
Fertigation duration	Fertigation levels
D_1: Fertigation upto 3.5 months	L_1: 75 % RDF
D_2: Fertigation upto 5.0 months	L_2: 100 % RDF
D_3: Fertigation upto 6.5 months	L_3: 125 % RDF
D_4: Fertigation upto 8.0 months	Control: Soil application of 100 % RDF with surface irrigation.
D_5: Fertigation upto 9.5 months	(RDF-250:100:125 NPK kg ha^{-1})
DAP-Days after planting/Ratoon initiations	NS= Non-significant

due to the inadequate supply of the required plant nutrients and irrigation water. The findings are in line with those of Kittad (1995) who observed declined trend in tiller production when surface irrigation was adopted for fertilizer application with surface irrigation, nutrients was applied to the top soil layer. This layer was subjected to alternate drying and wetting cycles due to longer irrigation intervals. Low soil water content as well as higher fixation with soil colloids had reduced the availability of applied nutrients that led to lower uptake of nutrients by the sugarcane crop. Similar absorption pattern with varying irrigation methods was narrated by Escobar (1995).

Conclusion :

Sugarcane is a major cash crop in India, cane growth being critically dependant on supply of water and nutrients. Experiments carried out over two seasons are reported here in which SSDF was compared with conventional irrigation with recommended doses of chemical fertilizers. Results demonstrated that by using SSDF it is possible to achieve higher cane growth and at the same time reduce fertilizer requirement.

Acknowledgement :

I am thankful to my chairman Dr. Nagaraju Comptroller, UAS, GKVK, Bengaluru, advisory members Dr. B. Mohan raju Professor, Department of Crop Physiology and Dr. M.N. Thimmegowda Associate Professor, Department of Agronomy for their kind guidance, motivation for my Ph.D. research work.

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