Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.7218

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **6 (6):** 862-868 (2018)

International Journal of Pure & Applied Bioscience

Research Article

OPEN ACCESS

Evaluation of Suitable Fertigation Interval and Fertilizer Level for Sugarcane under Subsurface Drip Fertigation

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Received: 6.11.2018 | Revised: 10.12.2018 | Accepted: 16.12.2018

ABSTRACT

A field experiment was conducted during 2015-16 and 2016-17 at Zonal Agricultural Research Station, V.C. Farm, Mandya to find out the suitable fertigation interval and optimum fertilizer level for sugarcane under subsurface drip fertigation. The treatment combinations consisting of three fertigation intervals (fertigation once in 2, 4, and 6 days) and four fertilizer levels (75, 100, 125 and 150% of recommended dose of fertilizers) along with conventional method of sugarcane cultivation were replicated thrice in factorial RCBD. Results indicated that, fertigation once in 2 days with 150 per cent RDF produced significantly 95.1 and 99.5 per cent higher cane yield (308.3 t ha^{-1} and 291.3 t ha^{-1} in plant and ratoon cane, respectively) than conventional method of cultivation (158.0 and 146.0 t ha^{-1}), fertigation once in 6 days with all levels of RDF, fertigation once in 2 or 4 days with 75 and 100 per cent RDF and was on par with fertigation once in 2 days with 125 per cent RDF and fertigation once in 4 days with 150 and 125 per cent RDF. Higher water use efficiency (2.58 and 2.40 t ha-cm^{-1}) with water saving of 56.23 per cent, higher net returns (Rs. 5,16,149 ha^{-1} and Rs. 5,34,527 ha^{-1}) and B:C ratio (3.18 and 3.95) in plant cane and ratoon cane, respectively were obtained with fertigation once in 2 days with 150 per cent RDF than conventional method (Rs. 2,36,618 and Rs. 2,29,300 ha^{-1} and 2.07 and 2.15) and other combinations of fertigation intervals and fertilizer levels under subsurface fertigation in sugarcane.

Key words: *Fertigation intervals, Fertilizer levels, Sugarcane, Yield and Water use efficiency.*

INTRODUCTION

Sugarcane (*Saccharum sp.*) is the world's most important commercial crop for the sugar industry. In India, sugar industry is one of the largest agro based processing industries. Sugarcane being a long duration crop, produces huge amount of biomass and requires large quantity of water compared to other crops. Water requirement of sugarcane under conventional method of cultivation varies from 2000 to 2500 mm depending upon soil type and climate[2,13]. Vagaries of monsoon and declining ground-water resource due to over exploitation have resulted in shortage of fresh water supply for agricultural use. Further, India's water demand will nearly double by 2030 from the present 740 billion m^3 to 1.3 trillion m^3, thus necessitating efficient water management for improving agricultural productivity[17].

Cite this article: Ningaraju, G.K., Shankaralingappa, B.C., Nagaraju and Ramachandra, C., Evaluation of Suitable Fertigation Interval and Fertilizer Level for Sugarcane under Subsurface Drip Fertigation, *Int. J. Pure App. Biosci.* **6(6):** 862-868 (2018). doi: http://dx.doi.org/10.18782/2320-7051.7218

In conventional method of irrigation and fertilizer application, there is considerable loss of water and leaching of mobile nutrients, particularly nitrogen[15] which in turn leads to pollution of water bodies and deterioration of soil health. Providing optimum soil condition throughout the growing period of sugarcane is of paramount importance to realize higher yields. Therefore, drip fertigation, one of the promising potential technologies offers the great scope to increase the cane productivity up to 200-220 t ha^{-1} by saving 40-50 per cent irrigation water with increase in nutrient efficiency by 40 per cent[16]. Pawar *et al.*[12] observed 27.3 per cent increase in cane yield with drip fertigation and 17.6 per cent increase in cane yield with 57 per cent water saving through drip irrigation.

Proper fertigation schedule is very important to exploit the full potential of sugarcane under subsurface drip fertigation. Fertigation should provide optimum concentration of nutrients in the root zone. Hence, accurate prediction of when and how much fertilizer to be applied is critical for fertigation management. Fertigation intervals is one of the major management variables in drip fertigation. Fertigation can be given once in a day or once in two days or once in a week or once in a fortnight depending on soil type and crop. It is often assumed that fertigation at shorter interval with drip irrigation is preferable than wide interval and literature available to support this view is meager. Evaluation of fertigation schedule *i.e*., quantity of fertilizers to be applied through fertigation and fertigation interval would be useful for sugarcane farmers to enhance the productivity. In order to achieve these objectives, a field experiment was conducted.

MATERIAL AND METHODS

The experiment was conducted at Zonal Agricultural Research Station, V. C. Farm, Mandya, during 2015-16 and 2016-17. The Soil of the experimental site was red sandy loam with low organic carbon (0.4%), medium available N (344.9 kg ha^{-1}), available P_2O_5 (36.2 kg ha^{-1}) and available K_2O (162.3 kg ha^{-1}). The experiment was laid out in Randomized Complete Block Design with factorial concept and replicated thrice. The treatments consisted of two factors *viz.*, threefertigation intervals (I_2: Fertigation once in 2 days, I_4: Fertigation once in 4 days and I_6: Fertigation once in 6 days) and four fertilizer levels (75, 100, 125 and 150% RDF) along with conventional method of sugarcane cultivation (soil application of recommended dose of fertilizer 250-100-125 kg N, P_2O_5 and K_2O ha^{-1} with surface irrigation). The land was prepared by ploughing with tractor drawn disc plough followed by disc harrowing and passing cultivator twice to bring the soil to fine tilth. Layout was prepared with gross plot size of 15.6 m × 8.0 m. Drip irrigation system (pump, filter units, main line and sub line) was installed. The laterals were placed at 195 cm apart. The drip line was passed in between 30 cm apart paired row at 10-20 cm below the soil surface. Inline emitters were placed 40 cm apart with discharge rate of 4 lph. Recommended FYM (25 t ha^{-1}) was applied one month before planting. 50 per cent P was applied as basal dose and remaining P was applied at 105 days after planting. N and K were applied through subsurface drip fertigation as per the fertigation in the intervals of once in 2days, 4days and 6days in 136, 68 and 45 equal splits respectively up to 9 months. Drip irrigation was scheduled uniformly for every two days to all the treatments based on daily pan evaporation.Viable and healthy two bud setts of variety Co- 86032 were planted in a zig-zag manner in paired row method of planting with spacing of 30/165 cm and intra row spacing of 30 cm. Atrazine 50 per cent WP at 1.0 kg ai ha^{-1} was sprayed 2 days after planting and two hand weeding were done at 45 and 90 days after planting to control weeds. Optimum plant population was maintained by filling the gaps at 30 DAP. Earthing up was carried out twice by tractor drawn implement. In each plot, five plants were selected randomly and tagged for recording growth and yield observations as per standard procedures and B: C ratio was calculated by using net returns and cost of

cultivation. The depth of water in surface method of irrigation was estimated using standardmethodology. The water requirement of the crop was determined by formula:

WR = IR + ER + S

Where, WR = Water requirement, (mm); IR = Irrigationrequirement, (mm); ER = Effective rainfall, (mm); S =Soil moisture contribution, (mm)

The soil moisture contribution was considered as nil asthe water table was too deep from soil surface. The fieldwater use efficiency (FWUE) of crop to total water usedduring its life period was estimated as;

$$\text{FWUE (kg ha–cm}^{-1}) = \frac{\text{Total yield (kg/ha)}}{\text{Total water applied (cm)}}$$

The data was statistically analyzed by following the method of Gomez and Gomez[5].

RESULTS AND DISCUSSION

Cane yield: The cane yield, irrespective of fertilizer levels, differed significantly due to fertigation intervals in both plant and ratoon sugarcane crop (Table 1). Fertigation once in 2 days (I_2) produced significantly higher cane yield (281.4 t ha^{-1} in plant crop and 263.0 t ha^{-1} in ratoon crop) than fertigation once in 6 days (I_6) (235.0 and 226.0 t ha^{-1}, respectively) and was on par with fertigation once in 4 days (267.5 and 248.0 t ha^{-1}, respectively). Similar increase in yield with the scheduling of fertigation with shorter intervals was reported by Raval *et al.*[14] and Nagaraju *et al.*[10]. Amala and Syriac[1] obtained higher fruit yield of tomato with fertigation once in 4 days than with fertigation once in 8 days. The increased cane yield when fertigation was given at shorter interval was mainly due to availability of nutrients regularly as per the crop demand. Delay in fertigation resulted in reduced cane yield due to lower availability of plant nutrients since, fertilizers applied through drip irrigation was water soluble and there was no buildup of nutrients in the soil[4]. Fertigation once in 6 days did not match with crop demand for nutrients and this resulted in reduced yield. Similar results were reported by Kumar *et al.*[9] and Raval *et al.*[14].

The cane yield of sugarcane was significantly influenced by fertilizer levels irrespective of fertigation intervals in both plant cane and ratoon cane (Table 1). Application of 150 per cent RDF, being on par with the application of 125 per cent RDF (273.7 t ha^{-1} in plant crop and 257.5 t ha^{-1} in ratoon crop) produced significantly higher cane yield in both plant crop and ratoon crop (285.4 and 270.9 t ha^{-1}, respectively) as compared to application of 100 per cent RDF (254.0 and 238.2 t ha^{-1} in plant and ratoon crop, respectively) which was significantly superior to 75 per cent RDF (231.9 and 216.1 t ha^{-1} in plant and ratoon crop, respectively). The results clearly indicated that under sub-surface drip fertigation in both plant crop and ratoon crop of sugarcane significantly responded to higher amount of fertilizers due to its higher cane yielding ability.

The interactions between fertigation intervals and fertilizer levels were significant on cane yield of sugarcane under drip fertigation in both plant crop and ratoon crop (Table 1). At all fertigation intervals, cane yield increased with increase in fertilizer levels. At all the fertilizer levels tried, cane yield increased with decrease in fertigation intervals from I_6 to I_2. Fertigation once in 2 days with 150 per cent of RDF (I_2F_4) produced significantly higher cane yield (95.1 and 99.5 per cent) in plant crop (308.3 t ha^{-1}) and ratoon crop (291.3 t ha^{-1}), respectively as compared to conventional method of cultivation (158.0 and 146.0 t ha^{-1} in plant crop and ratoon crop, respectively). Fertigation once in 2 days with 150 per cent of RDF supplied the NPK nutrients that matched with the crop growth demand throughout the crop growth period which might have favored faster cell division and cell elongation resulting in higher number of internodes[8].

Water use efficiency: The water use efficiency of sugarcane under subsurface drip fertigation was significantly affected by interactions between fertigation intervals and fertilizer levels in both plant crop and ratoon crop (Table 1). At all the intervals of fertigation, water use efficiency increased with increase in fertilizer levels. Likewise at all the fertilizer levels, water use efficiency increased with decrease in fertigation intervals from I_6 to I_2. The total water used (irrigation water + effective rainfall) in all the treatment combinations (three fertigation intervals and four fertilizer levels) for sugarcane under subsurface drip fertigation was same (1195 mm in plant cane and 1216 mm in ratoon cane) and was low as compared to the water used in the conventional method of cane cultivation (2403 mm in plant cane and 2440 mm in ratoon cane). The water use efficiency (WUE) was significantly higher with fertigation once in 2 days with 150 per cent RDF (I_2F_4) (2.58 t ha-cm^{-1} in plant crop and 2.40 t ha-cm^{-1} in ratoon crop) as compared to that with fertigation once in 6 days with all the levels of fertilizer (1.69 to 2.18 t ha-cm^{-1} in plant crop and 1.61 to 2.08 t ha-cm^{-1} in ratoon crop), I_4F_1, I_4F_2, I_4F_3, I_2F_1 and I_2F_2 and it was on par with I_2F_3 (2.46 and 2.27 t ha-cm^{-1} in plant crop and ratoon crop, respectively) and I_4F_4 (2.41 t ha-cm^{-1} in plant cane and 2.21 t ha-cm^{-1} in ratoon crop). Significantly higher WUE of sugarcane under drip fertigation once in 2 days with 150 per cent RDF over I_6F_1, I_6F_2, I_6F_3, I_6F_4, I_4F_1, I_4F_2, I_2F_1 and I_2F_2 was due to significantly higher cane yield indicating the efficient use of water in drip fertigation with higher amount of NPK fertilizers, though the total amount of water used in different combinations of fertigation intervals and fertilizers was the same. Significantly the lowest WUE was observed in conventional method of sugarcane cultivation (0.65 and 0.60 t ha-cm^{-1} in plant crop and ratoon crop, respectively). Lower WUE under conventional method over drip fertigation was due to significantly the lower cane yield (146.0 t ha^{-1}) with high irrigation water requirement (2148 mm in plant cane and 2222 mm in ratoon crop). Water saving and higher water use efficiency in drip fertigation was due to reduced percolation and seepage losses in addition to least conveyance and evaporation losses[6].

Economics: Higher cost of cultivation (₹. 1,62,111 ha^{-1} in plant crop and ₹. 1,35,386 ha^{-1} in ratoon crop), gross returns (₹. 6,78,260 ha^{-1} in plant crop and ₹. 6,69,913 ha^{-1} in ratoon crop), net returns (₹. 5,16,149 ha^{-1} in plant crop and ₹. 5,34,527 ha^{-1} in ratoon crop) with higher B:C ratio (3.18 in plant crop and 3.95 in ratoon crop) were observed in sugarcane under drip fertigation once in 2 days with 150 per cent of RDF as compared to those with other combinations of fertigation intervals and fertilizer levels (Table 2). The lowest cost of cultivation (₹. 1,13,982 ha^{-1} in plant crop and ₹ . 1,06,500 ha^{-1} in ratoon crop), gross returns (₹. 3,47,600 ha^{-1} in plant crop and ₹.3,35,800 ha^{-1} in ratoon crop), net returns (₹. 2,36,618 ha^{-1} in plant crop and ₹. 2,29,300 ha^{-1} in ratoon crop) with lower B:C ratio (2.07 in plant crop and 2.15 in ratoon crop) were noticed in conventional method of cultivation. Fertigation once in 2 days with 150 per cent of RDF (I_2F_4) registered higher net returns of 118.1 per cent in plant crop and 133.1 per cent in ratoon crop over conventional method, 21.6 per cent in plant crop and 22.9 per cent in ratoon crop over fertigation once in 4 days with 100 per cent of RDF (I_4F_2) and 15.9 per cent in plant crop and 17.4 per cent in ratoon crop over fertigation once in 2 days with 100 per cent of RDF (I_2F_2). Higher net returns with I_2F_4 over conventional method, fertigation once in 6 days with any fertilizer levels, I_4F_2, I_2F_2, I_2F_1, I_4F_1 was due to significantly higher cane yield (Table 1). Similar results of increased net returns from sugarcane under drip fertigation due to increased cane yield were reported by Gururaj Kombali[7] and Padmanabhan[11]. There was marginal increase in net returns with fertigation once in 2 days with 150 per cent of RDF (I_2F_4) over I_2F_3, I_4F_4 and I_4F_3. This marginal increase in net returns with I_2F_4 over I_2F_3, I_4F_4 and I_4F_3 was due to marginal/non-significant increase in cane yield. However, fertigation once in either 2

days or 4 days with either 125 or 150 per cent of RDF recorded higher net returns ranging from 93.1 to 106.0 per cent in plant cane and 103.9 to 119.2 per cent in ratoon cane over conventional method.

Table1: Yield, water used and water use efficiency of sugarcane as influenced by fertigation intervals and fertilizer levels

Treatments	Cane yield (t ha^{-1})		Water used (Iw+ER) (mm)		Water use efficiency (t ha-cm^{-1})	
	Plant cane	Ratoon cane	Plant cane	Ratoon cane	Plant cane	Ratoon cane
Fertigation intervals (I)						
I_2	281.4	263.0	1195	1216	2.36	2.16
I_4	267.5	248.0	1195	1216	2.24	2.04
I_6	235.0	226.0	1195	1216	1.97	1.86
S.Em ±	5.17	5.50	NA	NA	0.04	0.05
C.D. (p=0.05)	15.15	16.13	NA	NA	0.13	0.13
Fertilizer levels (F)						
F_1	231.9	216.1	1195	1216	1.94	1.78
F_2	254.0	238.2	1195	1216	2.13	1.96
F_3	273.7	257.4	1195	1216	2.29	2.12
F_4	285.4	270.9	1195	1216	2.39	2.23
S.Em ±	5.96	6.35	NA	NA	0.05	0.05
C.D. (p=0.05)	17.49	18.63	NA	NA	0.15	0.15
Interactions (I×F)						
I_2F_1	251.2	231.6	1195	1216	2.10	1.90
I_2F_2	272.7	253.5	1195	1216	2.28	2.08
I_2F_3	293.5	275.7	1195	1216	2.46	2.27
I_2F_4	308.3	291.2	1195	1216	2.58	2.40
I_4F_1	242.4	220.9	1195	1216	2.03	1.82
I_4F_2	261.7	243.2	1195	1216	2.19	2.00
I_4F_3	278.2	259.0	1195	1216	2.33	2.13
I_4F_4	287.7	268.6	1195	1216	2.41	2.21
I_6F_1	202.3	195.6	1195	1216	1.69	1.61
I_6F_2	227.7	217.7	1195	1216	1.91	1.79
I_6F_3	249.3	237.7	1195	1216	2.09	1.95
I_6F_4	260.4	252.7	1195	1216	2.18	2.08
S.Em ±	10.3	11.00	NA	NA	0.09	0.09
C.D. (p=0.05)	30.0	32.26	NA	NA	0.25	0.27
Conventional method	158.0	146.0	2403	2440	0.65	0.60
S.Em ±*	9.95	10.85	NA	NA	0.08	0.09
C.D. (p=0.05)*	29.03	31.66	NA	NA	0.24	0.26

Fertigation intervals
I_2: Fertigation once in 2 days
I_4: Fertigation once in 4 days
I_6: Fertigation once in 6 days
RDF=Recommended dose of fertilizers (250:100:125 kg N:P_2O_5:K_2O ha^{-1})
Conventional method: Soil application of 100% RDF with surface irrigation
*For comparing treatments with conventional method in simple RCBD

Fertilizer levels
F_1: 75% RDF
F_2:100% RDF
F_3:125% RDF
F_4:150% RDF

Table 2: Economics of sugarcane cultivation as influenced by fertigation intervals and fertilizer levels under subsurface drip fertigation

Treatments	Cost of cultivation (₹. ha^{-1})		Gross returns (₹. ha^{-1})		Net returns (₹. ha^{-1})		B:C ratio	
	Plant cane	Ratoon cane	Plant cane	Ratoon cane	Plant cane	Ratoon cane	Plant cane	Ratoon cane
I_2F_1	150818	124093	552640	532757	401822	408664	2.66	3.29
I_2F_2	154582	127857	599940	583127	445358	455270	2.88	3.56
I_2F_3	158346	131621	645920	634187	487574	502566	3.08	3.82
I_2F_4	162111	135386	678260	669913	516149	534527	3.18	3.95
I_4F_1	147418	120693	533500	508223	386082	387530	2.51	3.21
I_4F_2	151182	124457	575740	559360	424558	434903	2.71	3.49
I_4F_3	154946	128221	612040	595777	457094	467556	2.85	3.65
I_4F_4	158711	131986	632940	617933	474229	485947	2.89	3.68
I_6F_1	144018	117293	445060	449957	301042	332664	2.09	2.84
I_6F_2	147782	121057	501160	500863	353378	379806	2.39	3.14
I_6F_3	151546	124821	548680	546710	397134	421889	2.62	3.38
I_6F_4	155311	128586	572880	581363	417569	452777	2.69	3.52
Conventional method	113982	106500	347600	335800	236618	229300	2.07	2.15

Fertigation intervals
I_2: Fertigation once in 2 days
I_4: Fertigation once in 4 days
I_6: Fertigation once in 6 days

Fertilizer levels
F_1: 75% RDF
F_2: 100% RDF
F_3: 125% RDF
F_4: 150% RDF

Selling price of sugarcane ₹. 2200 t^{-1}
Conventional method=Soil application of 100% RDF with surface irrigation
RDF=Recommended dose of fertilizers (250:100:125 kg N:P_2O_5:K_2O ha^{-1})

CONCLUSION

This study showed the superiority of subsurface drip fertigation and fertigation intervals for sugarcane cultivation in Cauvery command area of Mandya district in respect of cane yield water use efficiency and economics of sugarcane cultivation as compared with surface irrigation and fertilizer application practice by the farmers. Subsurface drip irrigation is water saving irrigation technique together with application of water soluble nutrients directly to the crop root zone that can provide optimum moisture condition throughout the growth period with minimal human intervention. Therefore, it may be a sustainable irrigation and fertilizer application method for sugarcane cultivation with fertigation interval of once in 2-4 days with recommended RDF.

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