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RESEARCH ARTICLE :

Optimization nutrient levels and sources of nutrients for sustainable sugarcane initiative under sub surface drip fertigation system

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SUMMARY : Sugarcane being a giant crop producing huge quantity biomass generally demands higher amounts of water and nutrients. Sub surface drip fertigation is the best way of improving water and fertilizer use efficiency to meet the challenging demand of increased fertilizer requirement. Sub surface drip irrigation ensures supply of nutrients at the area of most intensive root activity thereby results in increased yield and returns to the farmer. A research trial was conducted to study the effect nutrient levels and sources of nutrients for sustainable sugarcane Initiative (SSI) under sub surface drip irrigation system involving three irrigation regimes (0.6, 0.8 and 1.0 Pan Evaporation Factor, PEF) in main plots and fertigation of solely through commercial fertilizers, partially through commercial and water soluble fertilizers with different sources. The crop was raised by adopting double side plating (zig zag planting at 60 cm) with 180 cm inter row spacing. Drip irrigation given in two days interval and fertigation given at six days interval from 15 DAP to 210 DAP. The result reveals that among the irrigation regimes, sub surface drip irrigation at 1.0 PEF registered higher number of tillers, millable canes (112. 99 thousands). With regard to the sources of nutrients, the highest tillers and millable canes were registered under fertigation of 75 % RDF (50 % P and K as basal, balance through water soluble fertilizers as Ultrasol – 9: 5:33, urea and SOP. The sub surface drip irrigation to SSI cane at 1.0 PEF with an interval of 2 days recorded the maximum cane (147.16 ton /ha) and sugar yield (18.41 ton/ha). Fertigation of 75 % RDF (50 % P and K as basal balance through WSF as Ultrasol – 9:5:33, urea and SOP to SSI) cane gave highest cane yield 135. 04 t/ha. With respect to interaction effect, irrigation at 1.0 PEF and fertigation of 75 % RDF (50 %P and K as basal balance through WSF as Ultrasol – 9:5:33, urea and SOP) registered to highest cane yield (156.25 t/ha) and sugar yield (19.94 ton /ha). The highest water use of 1684 mm was recorded in 1.0PEF compared to 1377 mm in 0.8 PEF and 1070 mm in 0.6 PEF. The highest water use efficiency and water productivity were observed in drip irrigation given at 0.6 PEF compared to other irrigation regimes due to less water use. The highest gross income, net return and B: C ratio (4.6) was registered when irrigation at 1.0 PEF and fertigation of 75 % RDF (50 %P and K as basal balance through WSF as Ultrasol – 9:5:33, urea and SOP).

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BACKGROUND AND OBJECTIVES

Sugarcane is a most important cash crop of India. It involves less risk and farmers are assured upto some extent about return even in adverse condition. In agriculture sector, sugarcane shared 7 per cent of the total value of agriculture output and occupied 2.6 per cent of India's gross cropped area. Sugarcane provides raw material for the second largest agro-based industry after textile (Status paper on Sugarcane, 2013).

In India the sugarcane productivity is stagnating, demand is increasing at the same time scope for extending the area is very much limited. Under these circumstances, the emphasis must be on increasing sugarcane productivity. The critical steps to achieve this process are good agronomic and crop management practices for higher yields. After the success of SRI in rice, WWF–ICRISAT ventured upon applying similar principles to sugarcane and SSI was launched in India and majorprinciples are: i) Raising nursery using single-budded chips ii) Transplanting young seedlings (25–30 days old) iii) Maintaining wide spacing (4 ft or more between rows and 2 ft within a row) in the main field. IV) Providing sufficient moisture and avoiding inundation of water (Natarajan and Biksham, 2011).

Sub surface drip irrigation is defined by American Society of Agricultural Engineers as "application of water below the soil surface through emitters with discharge rates generally in the same range as drip irrigation. It requires lateral placement below normal tillage depth or at a depth that would ensure lateral survival throughout the growing season implying some degree of permanence (Camp, 1998). The other advantages of sub surface drip irrigation arewater saving and less weed problem.The water soluble fertilizers are fully water soluble solid fertilizers having high content of primary nutrients with low salt index. The sources and levels of the water soluble fertilizers have to be optimized for cane under sustainable sugarcane Initiative. Hence, a study was carried out with an aim of fixing the optimum irrigation regime with sources and levels of water soluble fertilizers for cane under SSI.

RESOURCES AND METHODS

The study was conducted in the research farm of Agriculture College and Research Institute, Madurai during the year 2013 and 2014. The experimental soil was sandy clay loam with low N and medium P and K content. The bulk and particle density of the soil is 1.28 and 2.76 Mg/m^3. The pH and EC was7.1 and 0.51 respectively.The experimental field was ploughed with tractor drawn disc plough followed by two ploughing with cultivator and the clods were broken with rotovator to bring the soil to fine tilth. After uniform leveling, trenches were dug out at a width of 40 cm at 140 cm apart. The furrow depth was maintained at 30 cm. The sugarcane variety CO 86032 was used for this study. Trenches was opened at 1.8 m spacing with 40 cm width and 30 cm depth for laying subsurface drip irrigation system and laterals were laid with emitters facing upward. Drippers spacing = 30 cm. Discharge rate = 1.29 lph at 0.70 kg/cm^2 pressure. Sustainable sugarcane initiative system of sugarcane cultivation was adopted. Thirty days old single bud chip seedlings raised in pro trays were used for planting. Double side planting at 60 cm intra row spacing was adopted. The three irrigation regimes in main plot (0.6, 0.8 and 1.0 PEF) and four fertilizer levels (100% RDF P as basal, N and K through drip fertigation, 75 RDF (50% P and K as basal, balance as WSF) through different sources in sub plots was taken for the study. The recommended dose of fertilizer followed is 275:62.5:112.5 kg's NPK $ha^{-1.}$ Fertigation was given from 15 DAS with an interval of 7 days upto 210 DAS. The different sources water soluble fertilizer used are 13:40:13, Urea and SOP; 19:19:19, Urea and SOP and Ultrasol- 9:5:33, Urea and SOP. The sugarcane variety CO 86032 was used for this study. The experiment was laid in split plot with three replications. The different growth and yield parameter were measured by adopting standard procedure and methods. The USWB open pan evaporimeter available in the observatory of Agriculture College and Research Institute, Madurai is used to estimate the evaporation.

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads:

Number of tillers and millable cane production :

The number of tillers and millable cane production was significantly influenced by irrigation regimes and nutrient sources (Table 1). Among the irrigation regimes, irrigation at 1.0 PEF (Pan Evaporation Factor) recorded the highest number of tillers (118.19 thousands/ha)

followed by I_2 (irrigation at 0.8 PEF) with a value of 104.68. Lowest tillers of 92.78 thousands/ha was registered when irrigation given at 0.6 PEF (I_1). With regard to the nutrient sources, fertigation of 75 % RDF *i.e* 50% P and K as basal, balance through drip as water soluble fertilizers (Ultrasol 9:5:33), Urea and sulphate of potash (F_4) recorded highest number of tillers (108 thousands/ha) which was on par with all other treatments. With regard to the interaction effect, highest number of tillers are recorded when irrigation given at 1.0 PEF regime with fertigation of 75 % RDF *i.e* 50% P and K as basal, balance through drip as water soluble fertilizers (Ultrasol 9:5:33), Urea and sulphate of potash. The reason might be due to maintenance high soil moisture near to field capacity level during the cropping period by frequent application with correct source application of water soluble fertilizers results in fastest cell growth and elongation leads to more tillers and number of millable canes. These results are corroborated with the findings of Gurusamy *et al*., 2014. The same result of increased NMC under higher irrigation levels with fertigation was observed by Mahendran *et al*. (2005). He found that the number of millable cane had direct correlation with irrigation regime and fertigation level.

Individual cane weight and commercial cane sugar percentage :

Irrigation given at 1.0 PEF registered highest cane weight (1.61 kg) as compared to other irrigation regimes (Table 2). With regard to the nutrient sources, fertigation of 75 % RDF *i.e.* 50 per cent P and K as basal, balance through drip as water soluble fertilizers (Ultrasol 9:5:33), Urea and sulphate of potash (F_4) recorded highest number of tillers (108 thousands/ha) which was on par with F_3 (Fertigation of 75 % RDF *i.e.* 50 per cent P and K as basal, remaining amount through drip as WSF - 19:19:19, Urea and SOP). The interaction effect of irrigation with sources of nutrients elucidated that irrigation given at 1.0 PEF with F_4 as nutrient source recorded highest cane weight of 1.67 kg. Similar trend of results were obtained for the commercial cane sugar. The similar findings was reported by Chaudhari *et al.*, 2010 in sugarcane *i.e.* application of water soluble fertilizers registered highest growth and yield parameters compared to straight fertilizers.

Table 1: Effect of sub surface drip irrigation and sources of nutrients on tiller production and number of millable cane under SSI

	Tiller production (000/ha)				NMC (000/ha)			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
F_1	90.33	102.05	115.22	102.53	89.66	98.87	109.85	99.46
F_2	92.17	103.80	117.20	104.39	91.50	101.22	101.22	101.72
F_3	93.55	105.33	118.93	105.93	92.86	102.75	102.75	103.26
F_4	95.07	107.53	121.41	108.00	94.37	103.94	103.94	104.59
Pooled mean	92.78	104.68	118.19		92.10	101.69	101.69	
	I	F	IXF		I	F	IXF	
S.E.±	2.91	3.21	2.81		3.62	3.10	3.25	
C.D. (P=0.05)	5.81	6.42	5.62		6.29	6.11	6.52	

Table 2 : Effect of sub surface drip irrigation and sources of nutrients on individual cane weight (kg) and CCS under SSI

	Individual cane weight (kg)				CCS (%)			
Treatments	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
F_1	1.30	1.42	1.54	1.42	10.46	11.12	12.25	11.28
F_2	1.34	1.46	1.59	1.46	10.60	11.28	12.43	11.43
F_3	1.38	1.50	1.63	1.50	10.72	11.40	12.56	11.56
F_4	1.41	1.54	1.67	1.54	10.90	11.58	12.76	11.75
Pooled mean	1.36	1.48	1.61		10.67	11.34	12.50	
	I	F	IXF		I	F	IXF	
S.E.±	0.04	0.03	0.03		0.22	0.31	0.31	
C.D. (P=0.05)	0.08	0.06	0.07		0.45	0.62	0.62	

Cane yield and sugar yield :

The cane and sugar yield of cane was significantly influenced by irrigation regimes and nutrient sources (Table 3). Among the irrigation regimes, sub surface drip irrigation given at 1.0 PEF registered maximum cane yield of (147.16 ton/ha) and sugar yield (18.41 ton/ha) and this treatment was followed by 125.01 ton/ha. The lowest cane was registered in the I_3 (irrigation given at 0.6 PEF). With respect to the nutrient sources tried, fertigation of 75 % RDF *i.e.* 50 per cent P and K as basal, balance through drip as water soluble fertilizers (Ultrasol 9:5:33), Urea and sulphate of potash (F_4) recorded the highest cane (135.04 ton/ha) and sugar yield (16 ton/ha) and this treatment was on par with F_3 (Fertigation of 75 % RDF *i.e.* 50 per cent P and K as basal, remaining amount through drip as WSF - 19:19:19, Urea and SOP). The drip fertigation of 100 RDF (P as basal, N and K through drip as urea and MOP was recorded lowest cane (118.33 ton/ha) and sugar yield (13.46). The interaction effect of irrigation with sources of nutrients revealed that irrigation given at 1.0 PEF with fertigation of 75 and RDF *i.e.* 50 per cent P and K as basal, balance through drip as water soluble fertilizers (Ultrasol 9:5:33), Urea and sulphate of potash (F_4) registered highest cane yield of 156.25 ton/ha and sugar yield (19.94 ton/ha). The irrigation schedule of 0.6, 0.8, 1.0 and 0.8 Etc coupled with 80 per cent RDF gave significantly higher cane yield of 200 t ha^{-1} (Vaishnava *et al*., 2002). Mahesh (2009) reported that application of water soluble N, P and K fertilizers significantly increased the cane yield when compared to straight fertilizers under subsurface drip fertigation in sugarcane. These results are corroborated with the findings of Gurusamy *et al*., 2013.

Water use efficiency and water productivity :

The variation in water use efficiency and water productivity was observed among the irrigation regimes and different nutrient sources tried (Fig 1 and 2). The

Table 3 : Effect of sub surface drip irrigation and sources of nutrients on yield of sugarcane under SSI

Treatments	Cane yield (t/ha)				Sugar yield (t/ha)			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
F_1	99.19	118.89	136.91	118.33	10.38	13.23	16.78	13.46
F_2	104.79	125.45	144.78	125.01	11.12	14.15	17.99	14.42
F_3	109.34	130.74	150.72	130.26	11.72	14.91	18.93	15.18
F_4	113.19	135.68	156.25	135.04	12.33	15.72	19.94	16.00
Mean	106.63	127.69	147.16		11.39	14.50	18.41	
	I	F	I x F		I	F	I x F	
S.E.±	4.21	3.81			0.31	0.37	0.31	
C.D. (P=0.05)	6.42	7.62			0.62	0.74	0.62	

Table 4: Effect of sub surface drip irrigation and sources of nutrients on economics of sugarcane under SSI (2013-15)

Treatments	Cost of cultivation (Rs./ha)	Gross income (Rs./ha)	Net income (Rs./ha)	B:C
I_1F_1	77770	248020	170250	3.2
I_1F_2	86150	262028	175878	3.0
I_1F_3	85530	273396	187866	3.2
I_1F_4	84842	283022	198180	3.3
I_2F_1	77770	297330	219560	3.8
I_2F_2	86150	313722	227572	3.6
I_2F_3	85530	326955	241425	3.8
I_2F_4	84842	339327	254485	4.0
I_3F_1	77770	342330	264560	4.4
I_3F_2	86150	361998	275848	4.2
I_3F_3	85530	376838	291308	4.4
I_3F_4	84842	390667	305825	4.6

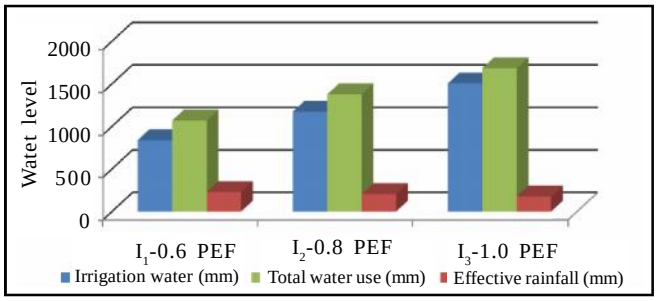

Fig. 1 : Water contribution from different sources

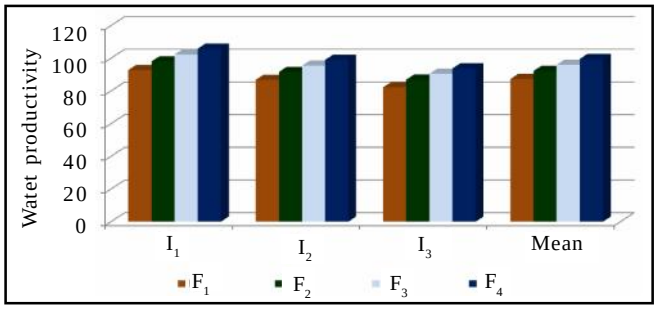

Fig. 2 : Effect of sub surface drip irrigation and sources of nutrients on water productivity of sugarcane under SSI

highest water use efficiency (99.8 kg/ha mm) and water productivity (Rs. 254.53 /ha mm) was observed under irrigation given at 0.6 PEF. The lowest water use efficiency and water productivity was registered when irrigation given at 1.0 PEF. Among the sources of nutrients, fertigation of 75 % RDF *i.e.* 50 per cent P and K as basal, balance through drip as water soluble fertilizers (Ultrasol 9:5:33), Urea and sulphate of potash (F_4) recorded highest water use efficiency of 99.60.

Economics :

Among the irrigation regimes, sub surface drip irrigation given at 1.0 PE and fertigation of 75 % RDF (50 % P and K as basal balance through WSF as Ultrasol – 9:5:33, urea and SOP).registered higher net income of Rs. 305825/ha with B:C ratio of 4.6 compared with other treatments.

Conclusion :

The sub surface drip irrigation to SSI cane at 1.0 PEF with an interval of 2 days recorded the maximum cane (147.16 ton /ha) and sugar yield (18.41 ton/ha). Fertigation of 75 % RDF (50 % P and K as basal balance through WSF as Ultrasol – 9:5:33, urea and SOP to SSI) cane gave highest cane yield 135. 04 t/ha. With respect to interaction effect, irrigation at 1.0 PEF and fertigation of 75 % RDF (50 % P and K as basal balance through WSF as Ultrasol – 9:5:33, urea and SOP) registered to highest cane yield (156.25 t/ha) and sugar yield (19.94 ton /ha).

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