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SOIL MOISTURE SENSOR BASED DRIP IRRIGATION ON SUGARCANE AT DIFFERENT FERTILIZER LEVELS

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Abstract

Field experiment was carried out to study the influence of irrigation system and fertigation levels on sugarcane under drip fertigation system at farmers field at Cuddalore district during 2015.The variety CO 86032 was used for the study. The experiment was conducted in split plot design treatments comprised with 18 combination treatments A) Main plot treatment: Irrigation system Treatments I_1 Subsurface Drip Irrigation at 75 % Etc,I_2 Subsurface Drip Irrigation at 100 % Etc,I_3 Subsurface Drip Irrigation at 125 % Etc, B)Subplot treatment: Fertigation levels Treatments, F_1 75 % RDF as commercial fertilizers, F_2 100 % RDF as commercial fertilizers, F_3 75 % RDF as 50 % commercial fertilizers + 50 % WSF, F_4 100 % RDF as 50 % commercial fertilizers + 50 % WSF, F_5 75 % RDF as WSF and F_6 100 % RDF as WSF. From the recent findings it was concluded that adoption of drip irrigation at 125 per cent Etc along with fertigation of 100 per cent RDF as water soluble fertilizer was found to record higher cane and sugar yield.

Keywords : Fertigation, Sugarcane, Soil moisture sensor.

Introduction

This Experiment explores the potential of WSN in the area of agriculture in India. Aiming at the sugarcane crop, a multiparameter monitoring system is designed based on low-power wireless communication technology for system automation and monitoring. Real time data is collected by wireless sensor nodes and transmitted to base station. Data is received, saved and displayed at base station to achieve soil temperature, soil moisture and humidity monitoring. The data is continuously monitored at base station and if it exceeds the desired limit, a message is sent to farmer on mobile through GSM network for controlling actions. The implementation of system software and hardware are given, including the design of wireless node and the implementation principle of data transmission and communication modules. This system overcomes the limitations of wired sensor networks and has the advantage of flexible networking for monitoring equipment, convenient installation and removing of equipment, low cost and reliable nodes and high capacity Continuous, real-time monitoring of soil-moisture is essential to effective and efficient water management in an automated drip irrigation system. Dukes *et al*., (2001) Francesca *et al*., (2010) Hence automated drip irrigation system is established with as per following.

1. Establishment of drip irrigation system
2. Placing of Soil moisture sensors at 15, 30 and 45 cm depths
3. Valve unit to control valve
4. Base station unit is programmed to read and to evaluate sensors data, control valves and to communicate with soil moisture sensor.
5. Software packages to collect, store, process and graphical display of soil and moisture data

Materials and Methods

Field experiment was carried out to study the influence of irrigation system and fertigation levels on sugarcane under drip fertigation system at Annamalai University Experimental Farm during 2012-2013. The sugarcane variety CO 86032 was used for this study. Two budded setts were planted on both sides of trenches with centre gap of 30 cm and the loose soil was filled to a depth of 5cm. Eight setts per running meter were planted on trench as continuous planting.The drip irrigation system was well maintained by flushing and cleaning the filters. Polyfeed (13-40-13) and potassium nitrate (13-0-46) of imported grade water soluble fertilizers and urea were used for fertigation. Single Super Phosphate and MOP (White potash) as a source of P and K were used for soil application. The recommended fertilizer dose of 3444:94:169 kg NPK ha^{-1} was followed in the experiment. Fertigation was given once in six days as per the treatment schedule starting from 15 to 210 DAP.

The main plot treatments comprised of different irrigation system Treatments *viz.,* I_1 Subsurface Drip Irrigation at 75 % Etc, I_2 Subsurface Drip Irrigation at 100 % Etc, I_3 Subsurface Drip Irrigation at 125 % Etc. and the subplot treatment includes different fertigation levels Treatments, *viz.,* F_1 75 % RDF as commercial fertilizers, F_2 100 % RDF as commercial fertilizers,F_3 75 % RDF as 50 % commercial fertilizers + 50 % WSF,F_4 100 % RDF as 50 % commercial fertilizers + 50 % WSF,F_5 75 % RDF as WSF,F_6 100 % RDF as WSFA control plot with surface irrigation and soil application of RDF (275:62.5:112.5 kg NPK ha^{-1}) was maintained separately.

Results and Discussion

Number of tillers (thousands ha^{-1})

The drip irrigation system and fertigation levels had significant influence on tiller production of planted crop (Table 1). The higher tiller production of 190.5 thousands ha^{-1} was observed with 125 per cent ETc with 100 per cent RDF as WSF at 90 DAP in plant crop. The combination of 125 per cent Etc with 100 per cent RDF as WSF recorded 30.7 per cent higher tillers when compared to 75 per cent ETc with 75 per cent RDF as commercial fertilizer and 15.2 and 35.8 per cent higher over control. The increase in number of tillers under subsurface drip fertigation was mainly due to early vigorous growth of the plant with the availability of required quantity of water and water soluble nutrients compared to lower irrigation regime and commercial fertilizer application wherein the fluctuation in nutrient availability was very wide. Continuous supply of water with plant nutrients might result in higher growth. Nitrogen was the prime promoter of tillering in sugarcane and protein synthesis was higher in tillering.Heiniger R (2013)

Table 1 : Effect of irrigation systems and fertigation levels on number of tillers (Thousands ha^{-1}) in plant crop

Treatments	Number of tillers (thousands ha^{-1}) at 90 DAP			
	T_1	T_2	T_3	Mean
F_1	145.8	158.6	166.9	157.7
F_2	149.1	165.2	170.4	161.6
F_3	150.1	168.9	178.5	165.8
F_4	152.8	172.6	182.5	169.3
F_5	163.0	175.6	186.3	175.0
F_6	167.1	178.2	190.5	178.6
	154.7	169.9	179.2	
	I	F	1XF	FXI
SEd	2.5	1.0	3.0	1.7
CD (0.05)	7.0	2.0	7.6	3.5
Control	165.3			

Number of millable canes (NMC)

Subsurface drip irrigation regimes and fertigation levels influenced the NMC in plant and ratoon crops. Table 2. Drip irrigation at 125 per cent Etc along with fertigation of 100 per cent RDF as WSF recorded 40.1 and 41.6 per cent higher NMC than 75 per cent Etc with 75 per cent RDF as commercial fertilizers. This was comparable with drip irrigation at 125 per cent Etc and fertigation of 75 per cent RDF as WSF.

Table 2 : Effect of irrigation system and fertigation levels on number of millable cane in Sugarcane.

Treatments	Number of millable cane (thousands ha^{-1})			
	T_1	T_2	T_3	Mean
F_1	107.9	118.6	124.2	116.9
F_2	110.2	125.7	133.4	123.1
F_3	113.5	130.8	138.6	127.6
F_4	115.6	135.7	142.6	131.3
F_5	120.4	137.1	147.0	134.8
F_6	126.9	139.5	151.2	139.2
	115.8	131.2	139.5	
	I	F	IXF	FXI
SEd	2.5	1.0	2.9	1.7
CD (0.05)	6.8	2.0	7.5	3.5
Control	86.9			

Cane Yield

Subsurface drip irrigation and fertigation positively influenced the yield of sugarcane. (Table 3). The cane yield was significantly improved by combined application of irrigation regimes, different dose and sources fertilizers through subsurface drip fertigation which could be due to boost tiller production, grand growth and biological efficiency of the cane. The combination of 125 per cent Etc along with 100 per cent RDF as WSF recorded higher cane yield of 240.7 t ha^{-1}. This was 64.5 percent increase over drip irrigation at 75 per cent Etc along with fertigation of 75 per cent RDF as commercial fertilizers in sugarcane.

When compared to control, 153.4 per cent increased yield was noticed in 125 per cent Etc along with 100 per cent RDF as WSF. The 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 resulted in increased total cane yield. 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 were increased significantly which ultimately resulted in increased production of cane yield.

Table 3 : Effect of irrigation system and fertigation levels cane yield (t ha-^{1}) in sugarcane

Treatments	**Cane yield (t ha^{-1})**			
	T_1	T_2	T_3	Mean
F_1	146.3	167.0	180.2	164.5
F_2	148.7	173.6	190.8	171.0
F_3	156.1	185.7	210.8	184.2
F_4	163.7	192.7	218.8	191.7
F_5	185.6	206.1	233.2	208.3
F_6	189.1	217.4	240.7	215.8
	164.9	190.4	212.4	
	I	F	IXF	FXI
SEd	4.9	2.4	6.2	4.2
CD (0.05)	13.5	4.9	15.4	8.6
Control	95.0			

These results are in agreement with the findings of Mahendran *et al*. (2005) who reported that fertigation up to 150 per cent of recommended dose of N and K in 14 equal splits up to 210 DAP to sugarcane crop resulted in higher cane yield of 173.5 t ha^{-1}. 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.

Sugar yield

Subsurface drip irrigation and fertigation had significantly influenced the sugar yield. (Table 4) Drip irrigation of 125 per cent Etc along with fertigiation of 100 per cent RDF as WSF recorded higher sugar yield of 29.1 which is 129.1 cent higher than the sugar yield obtained under control and 98.0 per cent higher compared to drip irrigation at 75 per cent Etc along with fertigiation of 75 per cent RDF as commercial fertilizers in planted crop. This finding were similar with Berrada *et al*., (2001)

The higher sugar yield under sub surface drip fertigation was mainly due to the availability of higher moisture with better aeration coupled with water soluble nutrients in all the stages of cane growth and water given based on the crop demand. These favorable environments resulted in better and earlier conversation of tillers to millable cane and the early vigor was maintained during the crop growth period due to continuous availability of nutrients and resulted in increased cane and sugar yield. The increased sugar yield was mainly due to improved juice quality parameters with the result of uniform millable cane production under this treatment.

Table 4 : Effect of irrigation system and fertigation levels sugar yield (t ha^{-1}) in sugarcane

Treatments	**Sugar yield (t ha^{-1})**			
	T_1	**T_2**	**T_3**	**Mean**
F_1	14.7	17.0	19.2	17.0
F_2	15.0	17.9	20.7	17.9
1F_3	15.9	19.7	23.3	19.6
F_4	16.9	20.8	25.0	20.9
F_5	19.7	23.3	27.7	23.5
F_6	20.4	24.9	29.1	24.8
	17.1	20.6	24.2	
	I	F	1XF	FXI
SEd	0.8	0.4	1.0	0.7
CD (0.05)	2.2	0.8	2.5	1.4
Control	12.7			

Water Use Efficiency (Kg ha^{-1} mm^{-1}) and Water productivity (Rs.mm^{-1})

Drip irrigation at 75 per cent Etc along with fertigation of 100 per cent RDF as WSF recorded higher WUE and water productivity in both crops (Table 5 and 6). The increase in WUE recorded under subsurface drip irrigation system was mainly due to better performance of the crop and increased yield by effective utilization of available water and nutrients that were supplied at regular intervals throughout the crop period to meet the crop demand. Abouatallaha *et al*. (2011) reported similar results

Table 5 : Effect of irrigation system and fertigation levels WUE (Kg ha^{-1} mm^{-1}) in sugarcane

Treatments	**WUE (Kg ha^{-1} mm^{-1})**			
	T_1	**T_2**	**T_3**	**Mean**
F_1	132.9	129.1	121.3	127.8
F_2	135.1	134.2	128.5	132.6
F_3	141.8	143.6	141.9	142.4
F_4	148.8	149.0	147.3	148.3
F_5	168.7	159.3	157.0	161.7
F_6	171.8	168.1	162.	167.3
	149.9	147.2	143.0	
	I	F	IXF	FXI
SEd	1.3	1.5	2.7	2.5
CD (0.05)	3.9	3.0	6.0	5.2
Control	51.8			

Table 6 : Effect of irrigation system and fertigation levels and water productivity (Rs.mm^{-1}) in Sugarcane

Treatments	Water productivity (Rs.mm^{-1})			
	T_1	T_2	T_3	Mean
F_1	166.1	161.4	151.7	159.7
F_2	168.9	167.8	160.6	165.7
F_3	177.3	179.4	177.4	178.0
F_4	185.9	186.2	184.1	185.4
F_5	210.8	199.2	196.3	202.1
F_6	214.8	210.1	202.6	209.2
	187.3	184.0	178.8	
	I	F	IXF	FXI
SEd	1.7	1.8	3.4	3.2
CD (0.05)	4.8	3.7	7.6	6.5
Control	64.7			

Economics

Subsurface drip fertigation is an innovative technology for maximizing the yield of cane crop. Though the cost of subsurface drip fertigation unit was very high, considering the longer life period of subsurface drip irrigation system, the benefit accrued out of drip irrigation will be for longer period. Fertigation involved an additional cost of using new specialty WSF viz., ployfeed-13:40:13, Multi K. However, the additional cost towards WSF was largely equalized by higher return obtained by higher cane and sugar yield with quality parameters. The economic parameters were higher in ratoon crop when compared to plant crop.

The higher cost of cultivation and gross return was notices with interaction of drip irrigation at 125 per cent Etc along with fertigation of 100 per cent RDF as WSF but 125 per cent with 75 per cent RDF as WSF registered higher net return of Rs.1,47,039 with 70.6 per cent increase compared to drip irrigation of 75 per cent Etc with fertigation of 75 per cent RDF as 50 per cent P and K in basal balance NPK through WSF in plant crop. Similar results reported by Hanson B, Orloff S (2002)

Drip fertigation of 100 per cent RDF as WSF at 125 per cent Etc recorded 224.0 per cent higher net return over surface irrigation with soil application of RDF. The higher BC ratio of 2.30 was registered under drip fertigation of 100 per cent RDF as commercial fertilizers in plant crops. The lower BC ratio was registered by drip irrigation at 75 per cent Etc with fertigation of 100 per cent RDF as WSF. This might be due to low cost of commercial fertilizers (Urea, SSP and MOP) whereas in water soluble fertilizer treatment the cost is very high.

Table 7 : Effect of irrigation system and fertigation levels on BC ratio in sugarcane

Treatments	BC ratio		
	T_1	T_2	T_3
F_1	2.03	2.15	2.28
F_2	2.01	2.20	2.32
F_3	1.79	2.00	2.15
F_4	1.73	1.92	2.08
F_5	1.75	2.00	2.02
F_6	1.62	1.77	1.89
		1.62	

From the foregoing, it is concluded that adoption of drip irrigation at 125 per cent Etc along with fertigation of 100 per cent RDF as water soluble fertilizer was found to record higher cane and sugar yield. The next best treatment in increasing cane and sugar yield was 125 per cent Etc with 75 per cent RDF as water soluble fertilizers. However based on BC ration and partial budgeting adoption of 125 per cent Etc along with 100 per cent RDF- P as basal (SSP) and N and K applied as urea and KCI through drip was found to be good.

Conclusion

Water is a limited resource in the world and agriculture is a primary market. Therefore, a sustainable and economic approach is to be adopted for efficient agricultural practice and irrigation scheduling (Levido *et al.,* 2014). The use of soil moisture sensors helps growers with irrigation scheduling by providing information about when to water the crops. Selection of sensor for a particular application on the basis of type of soil can become a tiresome exercise as there are wide level of soil moisture sensors available in the market. The advantages and disadvantages of sensors must be considered as criteria for selection because the working principle behind each type of sensor varies with its application and type of soil

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