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RESEARCH PAPER

Effect of subsurface drip fertigation on jaggery quality parameters of sugarcane

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Abstract : An experiment studying the effects of various levels of fertigation duration and fertigation levels on jaggery quality parameters of sugarcane using the variety CO86032 over two crop seasons (2014-15 and 2015-16) was conducted at ZARS, V.C. Farm, Mandya. Results revealed that jaggery quality parameters like juice extraction per cent, net rendament value, reducing sugars in jaggery and jaggery hardness did not differ significantly due to fertigation duration, fertigation levels and their interaction. Whereas, significantly higher jaggery recovery (13.82 and 13.45 %) and jaggery yield (31.92 and 28.19 t ha^{-1}) was recorded with fertigation duration upto 9.5 months in plant and ratoon cane at harvest, respectively. Jaggery recovery and jaggery yield significantly not influenced by fertigation levels. The interaction between fertigation duration and levels were significant. Fertigation upto 9.5 months with 125 per cent RDF recorded significantly higher jaggery recovery (13.96 and 13.55 %) and jaggery yield (32.21 and 28.91 t ha^{-1}) in plant and ratoon cane at harvest, respectively. 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 of RDF soil application recorded lower jaggery recovery (11.87 and 11.10 %) and jaggery yield (16.70 and 13.70 t ha^{-1}) of plant and ratoon cane at harvest, respectively. Experimental results clearly indicated that sub surface drip fertigation (SSDF) helps to increase the jaggery quality parameters over normal practice of sugarcane cultivation.

Key Words : Sub surface drip fertigation, Fertigation duration, Fertigation levels, Jaggery recovery

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INTRODUCTION

According to estimates of Anonymous (1976) and estimations by various agencies, the population of the country is expected to swell to 1.5 billion by 2030 AD at the present compound growth rate of 1.6 per cent per annum. It is estimated that the per capita consumption is likely to increase and may go upto 35 kg (both white sugar and *Gur*) by 2030 AD. At this rate of consumption and expected rise in population, the country may require nearly 52 million tonnes of sweeteners by 2030 AD. With decreasing trends in *Gur* and *Khandsari* production, the

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demand for white sugar is likely to increase to 33 million tonnes by 2030 AD. The emerging energy need of ethanol for blending in petrol will require additional sugarcane over and above the cane requirement to produce 33 million tonnes of sugar. In order to meet the growing demand of sugar and energy by 2030 AD in India, around 520 million tonnes of sugarcane with a recovery of 10.75 per cent will be required (312 million tonnes of cane exclusively for white sugar and additional 78 million tonnes of cane exclusively for ethanol production). Adoption of modern frontier technologies would become necessary to overcome many of the problems faced by sugarcane farmers. Under the circumstances, the technologies namely sub surface drip irrigation and fertigation will have to be put to use on farm level for enhancing production by monitoring crop condition and assessment of crop acreage and production.

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).

Net rendament value (NR) :

Net rendament values were calculated by substituting the jaggery quality values in the formula given below :

$$\text{Net rendement value} = \text{Sucrose (\%)} - \{\text{R.S \%} + (3.5 \times \text{Ash \%})\}$$

where,

R.S= Reducing sugar

Jaggery recovery (%) :

$$\text{Jaggery recovery (\%)} = \frac{\text{Weight of jaggery obtained x Total weight of juice}}{\text{Weight of juice used for jaggery preparation x Weight of cane}} \times 100$$

Jaggery yield (t ha^{-1}) :

Jaggery yield was calculated by multiplying cane yield (t ha^{-1}) with jaggery recovery per cent and it is expressed in tonnes ha^{-1}.

$$\text{Jaggery yield (t ha}^{-1}) = \frac{\text{Cane yield t ha}^{-1} \text{ x Jaggery recovery \%}}{100}$$

Reducing sugars in jaggery :

The reducing sugars were estimated by titrating the jaggery solution (10 g dissolved in 100 ml of water and clarified with lead sub acetate of activated charcoal) with 10 ml of Fehlings A + B solution as per Lane and Eynon volumetric method (Miller, 1998).

$$\text{RS in jaggery} = \frac{0.05 \text{ x Volume of jaggery solution}}{\text{Titer value x Weight of jaggery}} \times 100$$

Jaggery hardness :

Jaggery hardness was tested by using hardness tester by placing 3 cm^3 of jaggery in the hardness tester and force is applied to break the cube and the reading was recorded and it is expressed in kg cm^3.

RESULTS AND DISCUSSION

Jaggery quality parameters like juice extraction per cent, net rendament value, reducing sugars in jaggery

and jaggery hardness did not differ significantly due to fertigation duration, fertigation levels and their interaction.

Drip fertigation upto 9.5 months recorded significantly higher jaggery recovery (13.82 and 13.45 %) in plant and ratoon cane (Table 1). Which was at par with drip fertigation upto 8.0 months (13.44 and 13.19 %) and drip fertigation upto 6.5 months (13.04 and 12.82 %) in plant and ratoon cane. Statistically there was no

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

Treatments	Juice extraction (%)		Net rendament value		Jaggery recovery (%)	
Fertigation duration (D)						
	Plant cane	Ratoon cane	Plant cane	Ratoon cane	Plant cane	Ratoon cane
D_1	62.59	60.90	61.69	60.91	12.36	11.86
D_2	62.80	61.81	61.88	61.33	12.72	12.31
D_3	63.02	62.64	62.11	61.86	13.04	12.82
D_4	63.68	63.17	62.60	62.37	13.44	13.19
D_5	64.65	63.62	63.52	62.78	13.82	13.45
S.E.±	1.76	1.16	1.12	0.86	0.34	0.33
C.D. (P=0.05)	NS	NS	NS	NS	0.97	0.95
Fertigation levels (L)						
L_1	63.18	62.19	62.16	61.69	12.94	12.60
L_2	63.33	62.38	62.38	61.84	13.07	12.72
L_3	63.54	62.72	62.54	62.02	13.22	12.85
S.E. ±	1.36	0.90	0.87	0.67	0.26	0.26
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Interaction (D×L)						
D_1L_1	62.53	60.61	61.61	60.80	12.20	11.70
D_1L_2	62.59	60.87	61.70	60.91	12.39	11.85
D_1L_3	62.66	61.22	61.77	61.03	12.51	12.03
D_2L_1	62.72	61.70	61.80	61.14	12.60	12.18
D_2L_2	62.80	61.81	61.89	61.26	12.73	12.26
D_2L_3	62.87	61.93	61.96	61.58	12.81	12.48
D_3L_1	62.94	62.27	62.04	61.72	12.90	12.70
D_3L_2	63.01	62.63	62.10	61.87	13.02	12.83
D_3L_3	63.10	63.02	62.19	62.00	13.18	12.95
D_4L_1	63.47	63.08	62.25	62.18	13.30	13.09
D_4L_2	63.66	63.16	62.63	62.36	13.41	13.20
D_4L_3	63.91	63.26	62.93	62.56	13.62	13.27
D_5L_1	64.22	63.31	63.11	62.62	13.70	13.35
D_5L_2	64.60	63.40	63.58	62.78	13.81	13.46
D_5L_3	65.13	64.17	63.87	62.94	13.96	13.55
Control	60.96	59.71	60.90	59.91	11.87	11.10
S.E.±	3.04	2.02	1.94	1.49	0.58	0.57
C.D. (P=0.05)	NS	NS	NS	NS	1.68	1.65

Note:

Factor A:
Fertigation duration
D_1: Fertigation upto 3.5 months
D_2: Fertigation upto 5.0 months
D_3: Fertigation upto 6.5 months
D_4: Fertigation upto 8.0 months
D_5: Fertigation upto 9.5 months
NS= Non-significant

Factor B:
Fertigation levels
L_1: 75 % RDF
L_2: 100 % RDF
L_3: 125 % RDF
Control: Soil application of 100 % RDF with surface irrigation (RDF-250:100:125 NPK kg ha^{-1})

significant difference due to drip fertigation level in jaggery recovery. Significant differences were observed with interaction effect of drip fertigation duration and levels. Drip fertigation upto 9.5 months with 125 per cent RDF recorded significantly higher jaggery recovery (13.96 and 13.55 %) and at par results were recorded with drip fertigation upto 9.5 months with 100 per cent RDF (13.81 and 13.46 %), with 75 per cent RDF (13.70 and 13.35 %) in plant and ratoon cane, respectively. However, at par results were observed with drip fertigation upto 8.0 and 6.5 months *i.e.*, drip fertigation upto 8.0 months with 125 per cent RDF (13.62 and 13.27 %), with 100 per cent RDF (13.41 and 13.20 %) and with 75 per cent RDF (13.30 and 13.09 %) in plant and ratoon cane, respectively. Drip fertigation upto 6.5 months with 125 per cent RDF (13.18 and 12.95 %), with 100 per cent RDF (13.02 and 12.83 %) and with 75 per cent RDF (12.90 and 12.70 %) in plant and ratoon cane,

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

Treatments	Jaggery yield (t ha^{-1})		Reducing sugars in jaggery (%)		Jaggery hardness (kg cm^3)	
Fertigation duration (D)						
	Plant cane	Ratoon cane	Plant cane	Ratoon cane	Plant cane	Ratoon cane
D_1	23.18	20.11	12.79	12.51	2.17	2.15
D_2	25.20	21.05	12.62	11.96	2.14	2.13
D_3	28.03	23.19	12.45	11.62	2.11	2.10
D_4	30.51	26.03	12.28	11.26	2.08	2.06
D_5	31.92	28.19	11.92	10.86	2.06	2.00
S.E.±	1.00	1.08	0.30	0.70	0.05	0.06
C.D. (P=0.05)	2.89	3.11	NS	NS	NS	NS
Fertigation levels (L)						
L_1	27.09	22.94	12.50	11.78	2.12	2.10
L_2	27.79	23.80	12.41	11.64	2.11	2.09
L_3	28.42	24.40	12.33	11.51	2.10	2.07
S.E. ±	0.78	0.83	0.24	0.54	0.04	0.05
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Interaction (D×L)						
D_1L_1	22.62	19.85	12.84	12.71	2.18	2.16
D_1L_2	23.19	20.10	12.79	12.48	2.17	2.15
D_1L_3	23.74	20.37	12.73	12.35	2.17	2.15
D_2L_1	24.67	20.60	12.68	12.11	2.15	2.14
D_2L_2	25.00	21.04	12.61	11.95	2.14	2.13
D_2L_3	25.94	21.52	12.57	11.83	2.13	2.12
D_3L_1	27.16	21.94	12.50	11.72	2.12	2.11
D_3L_2	27.94	23.62	12.46	11.63	2.10	2.10
D_3L_3	29.00	24.00	12.39	11.51	2.10	2.09
D_4L_1	29.54	24.87	12.34	11.40	2.09	2.08
D_4L_2	30.79	26.00	12.28	11.28	2.08	2.06
D_4L_3	31.21	27.21	12.22	11.11	2.07	2.05
D_5L_1	31.49	27.45	12.11	10.97	2.06	2.05
D_5L_2	32.06	28.22	11.90	10.86	2.06	2.04
D_5L_3	32.21	28.91	11.74	10.74	2.05	2.03
Control	16.70	13.70	11.55	10.37	2.12	2.10
S.E. ±	1.73	1.86	0.53	1.22	0.09	0.08
C.D. (P=0.05)	5.01	5.38	NS	NS	NS	NS

Note:

Factor A: Fertigation duration
D_1: Fertigation upto 3.5 months
D_2: Fertigation upto 5.0 months
D_3: Fertigation upto 6.5 months
D_4: Fertigation upto 8.0 months
D_5: Fertigation upto 9.5 months

Factor B: Fertigation levels
L_1: 75 % RDF
L_2: 100 % RDF
L_3: 125 % RDF

Control: Soil application of 100 % RDF with surface irrigation (RDF-250:100:125 NPK kg ha^{-1})

NS= Non-significant

respectively. Soil application of 100 per cent RDF with surface irrigation recorded significantly lower jaggery recovery of (11.87 and 11.10 %) in plant and ratoon cane, respectively.

Drip fertigation upto 9.5 months recorded significantly higher jaggery yield (31.92 and 28.19 t ha^{-1}) in plant and ratoon cane, respectively. Which was at par with drip fertigation upto 8.0 months (30.51 and 26.03 t ha^{-1}) in plant and ratoon cane, respectively. Statistically there were no significant difference due to drip fertigation level in jaggery yield. Significant differences were observed with interaction effect of drip fertigation duration and levels. Drip fertigation upto 9.5 months with 125 per cent RDF recorded significantly higher jaggery yield (32.21 and 28.91 t ha^{-1}) and at par results were recorded with drip fertigation upto 9.5 months with 100 per cent RDF (32.06 and 28.22 t ha^{-1}), with 75 per cent RDF (31.49 and 27.45 t ha^{-1}) in plant and ratoon cane, respectively (Table 2). However, at par results were observed with drip fertigation upto 8.0 months with 125 per cent RDF (31.21 and 27.21 t ha^{-1}), with 100 per cent RDF (30.79 and 26.0 t ha^{-1}) and with 75 per cent RDF (29.54 and 24.87 t ha^{-1}) in plant and ratoon cane, respectively. Soil application of 100 per cent RDF with surface irrigation recorded significantly lower jaggery yield of (16.70 and 13.70 t ha^{-1}) in plant and ratoon cane, respectively.

Jaggery quality parameter is mainly dependent on the reducing sugars. TSS, purity and CCS per cent were influenced by higher moisture and nutrients resulted in higher jaggery quality parameters (Jayabal, 1997). Vasane *et al.* (2008) observed higher juice quality parameters of sugarcane like TSS (total soluble solids), sucrose, purity and CCS per cent and were significantly superior under subsurface drip irrigation resulting in higher jaggery quality parameters compared to other irrigation methods. Higher jaggery hardness was mainly due to lower moisture content under fertigation upto 3.5 months. Soil application of 100 per cent RDF with surface irrigation recorded lower jaggery quality parameters and this might be due to differences in water and nutrient availability to sugarcane. Similar results were also reported by Aluri (1998) who reported water stress during crop growth stages affect the jaggery quality parameters of the cane compared to sugarcane grown under conditions of suitable soil water availability.

Conclusion :

The manufacture of *Gur* and *Khandsari* sugar is an indigenous cottage industry of India. During 1950, almost ninety per cent of cane was utilized for *Gur, Shakkar* and *Khandsari* sugar manufacture. With the advent of sugar industry, cottage industry gradually vanished during 2006-07, hardly 16 per cent of cane was consumed in cottage industry and some 74 per cent crushed in sugar mills for white sugar production. Besides fast development of sugar industry, the cottage industry still dominates in India for *Gur* and *Khandsari* sugar manufacture. The experimental results revealed that jaggery quality parameters were not affected by the adaption of SSDF (Subsurface drip fertigation) for sugarcane cultivation.

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