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RESEARCH ARTICLE :

Performance of sugarcane ratoon under precision water and nutrient management

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SUMMARY : Field experiment was conducted during 2014-15 at Agricultural Research Station, Mudhol, to evaluate different methods of irrigation to achieve higher target yield levels on performance of ratoon sugarcane. The experiment was laid out in split plot design with 12 treatment combinations and three replications. Among the irrigation methods, subsurface (137 t ha^{-1}) and surface drip irrigation (125 t ha^{-1}) recorded significantly higher cane yield and yield parameters. Among the target yield levels, significantly higher cane yield was observed with target yield of 200, 250 and 300 t ha^{-1} than RDF. Subsurface drip irrigation in combination with 300 t ha^{-1} target yield level recorded significantly higher cane yield (179 t ha^{-1}) which was on par with surface drip irrigation with 300 t ha^{-1} target yield level (161 t ha^{-1}). Lower cane yield was recorded in furrow irrigation with RDF (76 t ha^{-1}). The drip irrigation saved 71.6 per cent of irrigation water during ratoon crop as compared to surface irrigation besides improving water use efficiency. The other quality parameters like brix, CCS and purity % were did not show any significant difference due to treatment effects.

KEY WORDS :
Quality parameters, Ratoon, Sugarcane, Water use efficiency, Yield

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BACKGROUND AND OBJECTIVES

Sugarcane is an important industrial crop of India being a long duration crop, requires considerable quantity of water to the extent of 1400 – 1500 mm in the subtropics (Solomon, 2012). Irrigation to sugarcane in the canal command area is mostly practiced by the furrow irrigation method with poor irrigation efficiency (40-45 %) (Shekinah and Rakkiyappan, 2011). Besides this, furrow irrigation leads to land degradation indifferent irrigation command areas. Sugarcane is one of the world's thirstiest crops, approximately 25,000 kg of water is needed to produce 100 kg of sugarcane. Under the circumstances of high water demand, drip irrigation in sugarcane holds promise as this method saves a substantial amount of irrigation water over the furrow irrigation method (Kaushal *et al.*, 2012).Consumption of sugar in India is increasing with time and by 2025 there is an expected gap of 11.9 MT between demand and supply of sugar. The area under cane cultivation is not likely to increase and the increasing demand has to be achieved from the same area through improved productivity

(Nair, 2009). Ratooning is an important practice in sugarcane growing. In India, keeping two or three ratoons is a common practice and almost more than 50 to 55 % of the total cane area always comes under ratoon crop (Dev *et al.*, 2011). In general, ratoon crop are poor cane yielder than their corresponding plant crops which are often poor yielder than the plant cane due to non adoption of improved agricultural technologies. Therefore, even a small improvement in ratoon, productivity would add considerably to overall sugarcane production in the country. Keeping these points in view a field experiment was conducted to know the performance of sugarcane ratoon under irrigation methods and target yield levels.

RESOURCES AND METHODS

Field experiment was conducted at Agricultural Research Station, Mudhol, University of Agricultural Sciences, Dharwad, during 2014-15 season under irrigated condition to study the performance of sugarcane ratoon under irrigation methods and target yield levels. The experiment was laid out in split plot design consisting of 3 main plots (Sub surface drip, surface drip and furrow irrigation) and 4 sub plots (target yield of 200, 250, 300 t ha^{-1} and RDF) with three replications. Prior to experiment the whole experimental field was divided into 20 X 20 m grids and soil samples were drawn from each grid to know the soil spatial variability for major nutrients. Nutrient status for the entire study area was low in nitrogen (132.7 kg ha^{-1}), low in phosphorus (22.6 kg ha^{-1}) and high in potash (652.3 kg ha^{-1}). Nutrient requirement was worked out by uptake studies as recommended by Zende, 1998. Based on that, if the nutrient status was high in the soil then 20 per cent was deducted, if the nutrient status was medium nutrients were applied as it is and if the nutrient status of the soil was low,20 per cent was added extra. Entire P_2O_5 was applied as basal and N and K_2O in 8 equal splits scheduled at monthly intervals. The surface and sub surface drip systems were installed after land and seed bed preparation. The sub lines are installed at intermittent distances and drip lines are laid between rows and covered by ridger in sub surface drip. In surface drip irrigation block drip lines are remained above the ground along with crop rows. Immediately after harvest of plant crop trash mulching was done between rows and stubble shaving and roto slasher was done to ensure uniform germination and early decomposition of trash. The observations on all yield parameters and yield were recorded as per the standard procedure and were statistically analyzed as per the methodology suggested by Gomez and Gomez (1984). The mean value of main plot, sub-plot and interaction effects were separately subjected to Duncan's Multiple Range Test (DMRT) using the corresponding error mean sum of squares and degrees of freedom values under by using M-STATC.

OBSERVATIONS AND ANALYSIS

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

Cane and sugar yield :

The cane and sugar yield of sugarcane varied significantly due to irrigation methods (Table 1). Among the irrigation methods sub surface drip irrigation (137 and 16.91 t ha^{-1}) and surface drip irrigation (125 and 15.51 t ha^{-1}) recorded significantly higher cane and sugar yield over furrow method of irrigation (96 and 11.87 t ha^{-1}). The increase in cane yield was to the extent of 42.7 and 30.2 per cent in ratoon crop over furrow irrigation. Increase in cane yield was mainly attributed to the application of nutrients in water soluble forms resulted in higher cane yield than application of nutrients in solid form (Bhunia *et al.*, 2013). Among the target yield levels, target yield of 300 t ha^{-1} recorded significantly higher cane and sugar yield (153 and 19.07 t ha^{-1}) than RDF (88 and 10.78 t ha^{-1}). The increment in cane yield was to the tune of 42.4 per cent over RDF. The results are in accordance with the Shree Harshakumar and Gaddanakeri (2015).

Significant differences were observed due to interaction of methods of irrigation and target yield levels with regard to cane and sugar yield (Table 1). Significantly higher cane yield (179 t ha^{-1}) was recorded in I_1S_3 than other treatment combinations. However, I_2S_3 (161 t ha^{-1}) and I_1S_2 (152t ha^{-1}were found on par with I_1S_3. The yield increment was to the tune of 57.5 per cent in I_1S_3 over I_3S_4. Highest shoot population coupled with efficient conversion of tillers into millable canes at harvest might have contributed to higher cane yield. Since the sugar yield is dependent on cane yield, it followed the same pattern as that of the cane yield. Similar trend was observed with respect to sugar yield whereas significantly higher sugar yield was observed in I_1S_3(22.24 t ha^{-1}) and it was comparable with I_2S_3 and I_1S_2. In drip fertigation, water and nutrients are supplied directly to the root zone using a network of tubes and dippers/emitters nozzles placed along the water-delivery line. This involves precise control and manipulation of soil moisture and nutrient temporally and spatially, which improves water economy, growth and ultimately crop yield. Similar reports were earlier reported by Gurusamy *et al.* (2013).The favorable influence on cane weight was occurred due to supply of required quantity of water and nutrients at the right time and at right place. These finding are in close agreement with the findings of Pawar *et al.* (2014).

Among the irrigation methods sub surface drip irrigation (112.86 thousands $ha^{-1}$and 1.20 kg) and surface drip irrigation (110.76 thousands ha^{-1}1.12 kg) recorded significantly higher NMC and single cane weight over furrow method of irrigation (104.03 thousands $ha^{-1}$and 0.98 kg). Among the target yield levels, S_3 (target yield of 300 t ha^{-1}) recorded significantly higher NMC (117.13 thousands ha^{-1}) than S_4 (96.18 thousands ha^{-1}). However, S_1 and S_2 target yield levels are on par with S_3(Table 1). Significant differences were observed due to interaction of methods of irrigation and target yield levels with regard to NMC and single cane weight. All the drip irrigated combinations with target yield levels combinations recorded significantly higher NMC over RDF combinations with drip and furrow irrigation. Similar findings were also reported by Deshmukh *et al.* (2010) who reported that significantly higher NMC achieved with drip fertigation in thirteen equal splits.

Juice quality parameters:

Analysis of quality parameters after harvest of ratoon cane indicated that, irrigation methods did not differ significantly with all quality parameters (Table 2). With respect to target yield levels, significantly higher juice and Pol per cent were recorded in target yield of 300 t ha^{-1} (60.33and 17.82, respectively) over RDF. The target

Table 1 : Number of millable canes (NMC), single cane weight, cane yield and sugar yield of sugarcane ratoon as influenced by irrigation methods and target yield levels

Treatments	NMC ('000 ha^{-1})	Single cane weight (kg)	Cane yield (t ha^{-1})	Sugar yield (t ha^{-1})
Irrigation methods (I)				
I_1 – Sub-surface drip irrigation	112.86a	1.20a	137a	16.91a
I_2–Surface drip irrigation	110.76a	1.12a	125b	15.51b
I_3– Furrow irrigation	104.03b	0.98b	96c	11.87c
S.E. ±	10.40	0.03	2.80	0.35
Target yields (S)				
S_1 – 200 t ha^{-1}	109.29a	0.99bc	109c	13.36c
S_2 – 250 t ha^{-1}	114.27a	1.11b	127b	15.84b
S_3 – 300 t ha^{-1}	117.13a	1.30a	153a	19.07a
S_4 – RDF	96.18b	0.92c	88d	10.78d
S.E. ±	29.87	0.0.5	5.80	0.73
Interaction (I X S)				
I_1S_1	114.60a-c	1.07cd	123b-d	15.12b-d
I_1S_2	118.37ab	1.29a-c	152ab	18.88ab
I_1S_3	120.44a	1.49a	179a	22.24a
I_1S_4	98.04cd	0.95d	93d-f	11.38d-f
I_2S_1	110.93a-c	1.04cd	115c-e	14.14c-e
I_2S_2	115.91ab	1.11b-d	128bc	15.97bc
I_2S_3	118.43ab	1.37ab	161a	20.22a
I_2S_4	97.77cd	0.98d	95c-f	11.70d-f
I_3S_1	102.34b-d	0.86d	88ef	10.81ef
I_3S_2	108.53a-d	0.93d	102c-f	12.65c-f
I_3S_3	112.53a-c	1.05cd	119c-e	14.75c-e
I_3S_4	92.74d	0.82d	76f	9.27f
S.E. ±	51.74	0.08	10.05	1.26

Means followed by the same letter (s) within a column are not significantly differed by DMRT (P=0.05) yield of 200 and 250 t ha^{-1} were comparable with S_3. Similarly among the interactions significantly higher juice and pol per cent were recorded with I_1S_3 (63.23 and 17.88). However, all other interactions were on par with I_1S_3 except I_3S_4 which recorded significantly lower juice and pol %. Similar reports were reported in earlier studies by Hemalatha (2015). The other quality parameters like brix, CCS and purity % were did not show any significant difference due to treatment effects.

Water use efficiency:

The total water applied in drip and furrow irrigation treatments was 43.2 and 152.3, cm, respectively. The saving in irrigation water with drip irrigation over surface irrigation was 71.6 per cent (Table 3).Higher IWUE was observed with I_1S_3 (4.14 t ha-cm^{-1}) followed by I_2S_3 (3.72 t ha-cm^{-1}). Whereas, all the furrow method of irrigation combinations recorded lower IWUE as compared to subsurface drip and surface drip irrigation combinations. The study reveals that supplying water to soil and nearer to plant root zone without loss of water resulting in higher water productivity. Increase in water productivity in the present study was attributed to increased cane yield with available water consumption as compared to furrow

Table 2 : Quality parameters of sugarcane ratoon as influenced by irrigation methods and target yield levels

Treatments	Juice (%)	Brix (%)	Pol (%)	CCS (%)	Purity (%)
Irrigation methods (I)					
I_1 – Sub-surface drip irrigation	58.10a	19.63a	17.70a	12.36a	90.22a
I_2–Surface drip irrigation	57.56a	19.44a	17.68a	12.40a	91.00a
I_3– Furrow irrigation	55.33a	19.38a	17.59a	12.32a	90.81a
S.E.±	1.17	0.09	0.07	0.08	0.58
Target yields (S)					
S_1 – 200 t ha^{-1}	56.05b	19.32a	17.54b	12.28a	90.81a
S_2 – 250 t ha^{-1}	57.10ab	19.47a	17.76a	12.47a	91.26a
S_3 – 300 t ha^{-1}	60.33a	19.73a	17.82a	12.45a	90.38a
S_4 – RDF	54.51b	19.40a	17.51b	12.23a	90.27a
S.E.±	1.27	0.16	0.07	0.08	0.79
Interaction (I X S)					
I_1S_1	57.04ab	19.46a	17.57ab	12.27a	90.26a
I_1S_2	57.75ab	19.70a	17.80ab	12.44a	90.36a
I_1S_3	63.23a	19.89a	17.88a	12.46a	89.84a
I_1S_4	55.11b	19.45a	17.56ab	12.26a	90.24a
I_2S_1	56.58ab	19.37a	17.55ab	12.28a	90.61a
I_2S_2	58.41ab	19.39a	17.79ab	12.52a	91.76a
I_2S_3	61.13ab	19.73a	17.87ab	12.51a	90.59a
I_2S_4	54.14b	19.26a	17.51ab	12.27a	90.92a
I_3S_1	54.56b	19.11a	17.49ab	12.30a	91.51a
I_3S_2	55.19b	19.33a	17.69ab	12.44a	91.54a
I_3S_3	56.84ab	19.57a	17.72ab	12.39a	90.55a
I_3S_4	54.09b	19.50a	17.47b	12.16a	89.59a
S.E.±	2.20	0.27	0.12	0.14	1.36

Means followed by the same letter (s) within a column are not significantly differed by DMRT (P=0.05)

Table 3: Irrigation water use efficiency (IWUE) of sugarcane ratoon as influenced by irrigation methods and target yield levels

	Subsurface drip (I_1)		Surface drip (I_2)		Furrow irrigation (I_3)	
	Irrigation water applied (cm)	IWUE (t/ha-cm)	Irrigation water applied (cm)	IWUE (t/ha-cm)	Irrigation water applied (cm)	IWUE (t/ha-cm)
S_1- 200 t ha^{-1}	43.2	2.80	43.2	2.66	152.3	0.57
S_2- 250 t ha^{-1}	43.2	3.50	43.2	2.96	152.3	0.66
S_3- 300 t ha^{-1}	43.2	4.14	43.2	3.72	152.3	0.78
S_4- RDF	43.2	2.15	43.2	2.19	152.3	0.40

Table 4 : Economics of sugarcane ratoon as influenced by irrigation methods and target yield levels

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
Irrigation methods (I)				
I_1–Sub-surface drip irrigation	85,139	2,73,230a	1,88,091a	3.16a
I_2–Surface drip irrigation	77,701	2,49,780b	1,72,079b	3.19a
I_3– Furrow irrigation	58,448	1,92,436c	1,33,989c	3.27a
S.E.±	-	55,96	55,96	0.10
Target yields (S)				
S_1–200 t ha^{-1}	70,509	2,17,545c	1,47,035c	3.09b
S_2–250 t ha^{-1}	77,128	2,54,034b	1,76,905b	3.29a
S_3–300 t ha^{-1}	84,257	3,06,140a	2,21,883a	3.63a
S_4–RDF	63,155	1,76,211d	1,13,055d	2.82b
S.E.±	-	11,609	11,609	0.15
Interaction (I X S)				
I_1S_1	81,417	2,46,239e	1,64,823e	3.02a-c
I_1S_2	89,317	3,03,359c	2,14,042c	3.40a-c
I_1S_3	96,984	3,57,565a	2,60,581a	3.69a
I_1S_4	72,838	1,85,758i	1,12,920i	2.55c
I_2S_1	74,284	2,30,431g	1,56,147f	3.10a-c
I_2S_2	80,889	2,55,159d	1,74,270d	3.15a-c
I_2S_3	89,097	3,22,889b	2,33,792b	3.62ab
I_2S_4	66,534	1,90,641i	1,24,107h	2.87bc
I_3S_1	55,828	1,75,963j	1,20,136i	3.15bc
I_3S_2	61,178	2,03,583h	1,42,404g	3.33a-c
I_3S_3	66,691	2,37,967f	1,71,276d	3.57a-c
I_3S_4	50,094	1,52,233k	1,02,139j	3.04bc
S.E.±	-	20,107	20,107	0.25

Means followed by the same letter (s) within a column are not significantly differed by DMRT (P=0.05)

irrigation. Similar findings were also reported Veeraputhiran *et al*. 2012 and Pawar *et al.* (2013).

Economics:

Economic analysis indicated that, significantly higher gross return(Rs. 2,73,230 ha^{-1}), net return (Rs. 1,88,091 ha^{-1}) was obtained with subsurface drip irrigation (Table 4). B:C ratio did not differ significantly among the irrigation methods. Among different targeted levels, significantly higher gross return (Rs. 3,06,140 ha^{-1}), net return (Rs.2,21,883 ha^{-1}) and B:C ratio (3.63) was obtained with target yield level of 300 t ha^{-1} (S_3) over target yield of 200 t ha^{-1} (S_1), 250 t ha^{-1} (S_2) and recommended dose of fertilizer (RDF). Among the interaction effects of irrigation methods and target yield levels, significantly higher gross return (Rs.3,57,565 ha^{-1}), net return (Rs.2,60,583 ha^{-1}) and B:C ratio (3.69) was obtained with I_1S_3 (subsurface drip irrigation with 300 t ha^{-1} target yield). All other treatment combinations were next in the order.

To conclude, either subsurface or surface drip irrigation with 300 t ha^{-1} target yield level was more productive and profitable, besides saving huge quantity of water and improving water use efficiency. However, surface drip method of irrigation with 250 t ha^{-1} target yield proves better for adoption at farmers' level.

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