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Effect of different irrigation level on growth, yield and quality of sugarcane

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Abstract: The experiment was conducted at Rajshahi Sugar mills zone, Rajshahi, Bangladesh during the period 2007-2008 to study the different irrigation level on growth, yield and quality of sugarcane. Five irrigation treatments viz., live irrigation at 0 and 14 days after plantation (I_1), I_1 + Irrigation at 21 days interval (I_2), I_1 + Irrigation at 28 days interval (I_3), I_1 + Irrigation at 35 days interval (T_4) and I_1 + Irrigation at 42 days interval (I_5) were used. Significantly highest yield and yield contributing characters were influenced by different level of irrigation. The highest number of tiller, number of millable cane, cane yield were obtained in I_2 (I_1 + Irrigation at 21 days interval) treatment. Significantly highest Brix (%), pol % cane and sugar yield were obtained in I_2 (I_1 + Irrigation at 21 days interval) treatment. The highest benefit cost ratio (BCR) was recorded in I_2 (I_1 + Irrigation at 21 days interval) treatment and lowest BCR was found in I_1 treatment (live irrigation at 0 and 14 days after plantation). The results indicated that I_2 (I_1 + Irrigation at 21 days interval) treatment was superior to any other irrigation treatment level in respect of cane yield, sugar yield and cash income.
Key words: Sugarcane, Irrigation, Cane yield and BCR

Introduction

Sugarcane is one of the most important food-cum-cash crop in Bangladesh but the average yield of the crop is too low in context to world average. The major causes of this low yield have been identified to be insufficient number of produced millable cane per unit area and lower unit stalk weight (Rahman *et al.*, 1987). Effective tillers are the principal functional unit which contributes to millable canes and ultimately to yield. Production of tillers in sugarcane are affected by several factors such as soil moisture level, date of planting/transplanting, variety, spacing, nutrition, intercultural operation etc. (Matin *et al.*, 1989). Tiller production and degree of its survivability are linked with planting/ transplanting techniques (Miah and Sarkar, 1982; Rahman *et al.*, 1987). As per Bangladesh climatic conditions, there is no rain or scanty rain during November to May. Plantation of sugarcane normally done during the month of October to February of the year and irrigation is essential for germination/establishment of sugarcane seedlings. From June to October, there is rainfall and the crop does not need irrigation. Rather in some places, the crop has to undergo water-logging sometimes for quite a long duration (about 1-3 months) which needs drainage. For judicious use of water for sugarcane from germination to harvest requires effective use of water at different interval and depth. The post-monsoon irrigation is ever done for sugarcane in Bangladesh. Therefore, the present investigation was undertaken to find out the effect of different irrigation levels on growth, yield and quality on sugarcane and to identify economically viable irrigation level compared to conventional method of irrigation.

Materials and Methods

The experiment was conducted at Rajshahi Sugar Mills Zone, Rajshahi, the year during 2007 to 2008. The experimental site belongs to High Ganges River Flood Plain Soils Agro ecological zone (AEZ -11) of Bangladesh. The experiment was laid out in a Randomized Complete Block Design with three replications. The unit plot size was 8m × 6m. The experimental crop was sugarcane (var. Isd 32), row to row spacing 1m and plant to plant spacing was 45cm. Planting material used in polybag settling. The experiment was set up on January 10, 2007 and harvesting date was January 18, 2008. The treatments were as: I_1: Live irrigation at 0 and 14 days after plantation, I_2: I_1 + Irrigation at 21days interval, I_3: I_1+ Irrigation at 28 days interval, I_4: I_1+ Irrigation at 35 days interval, I_5: I_1+ Irrigation at 42 days interval.

Number of irrigation applied: Number of irrigation and the day of application for different treatments during 2007-2008 are given in Table 1. Only two irrigation at 0 and 14 days after transplanting (DAT) were applied in treatment I_1. During 2007-2008, irrigation treatment I_1, I_2, I_3, I_4 and I_5 received 2, 7, 5, 5 and 4 numbers of irrigations respectively. The depth of irrigation was 10cm for each irrigation.

The fertilizers Urea, TSP, MOP, Gypsum and $ZnSo_4$ were applied @ 325, 250, 180, 190 and 9 kg ha^{-1}, respectively. Full quantity of TSP, Gypsum, $ZnSo_4$ and one-third of MOP were applied in trench and mixed with soil prior to transplanting of settlings. One-third of urea was applied at 21 days after transplanting (DAT). The second dose of ($1/3^{rd}$) urea and $1/3^{rd}$ MOP were applied as first top dressing at 90 DAT. Final top dressing of rest urea and MOP were applied at 150 DAT. To control insect pests, chlorpyrifos (trade name: regent 3 GR) was applied @ 33 kg ha^{-1} at the time of planting and carbofuran (trade name: furadan 5G) was applied @ 40 kg ha^{-1} in two splits from March to May, 2007. Other intercultural operations like weeding, mulching, gap filling, earthing-up, tying and cross tying were done as per schedule. Collection of data on yield and various yield contributing parameters of cane were done. Tiller population of sugarcane was recorded at 90, 120, 150 and 180 DAT. Millable cane and cane yield were recorded at harvest in the month of January, 2008. Economic and statistical analyses on different parameters of sugarcane were done following the standard procedures.

Chemical analysis of sugarcane juice: Chemical analysis of sugarcane juice for Brix (%), pol (%), purity (%) and reducing sugar (%) were done at harvest of sugarcane. Randomly selected 15 sample cane stalks were crushed with a mini power crusher to get juice for analysis. Brix was determined by Brix hydrometer standardized at 20^0C and sucrose determination was done using automatic Polarimeter (ADP-220) by Horne's dry lead method. Pol per cent cane was calculated by the method prescribed in Queensland Laboratory Manual (Anon, 1970), while

reducing sugars were measured by Lanc and Eynon method (Chen, 1985).

Table 1. Number and days of Irrigation application for different treatments (planted on January 10, 2007).

Irrigation	Treatments				
	I_1 (2 live irrigation)	I_2 (21 days interval)	I_3 (28 days interval)	I_4 (35 days interval)	I_5 (42 days interval)
No. of irrigation	2	7	5	5	4
Irrigation applied after transplanting (DAT)	0,14	0,14 35, 56, 77, 98, 119	0,14 42, 70, 98	0,14 49, 84, 119	0,14 56, 98

Brix (%): Percentage of total soluble solids present in solution (juice).

Purity (%): Percentage of pure sucrose in dry matter = (Pol ÷ Brix) × 100

Pol % Cane: Percentage of sucrose content in whole cane = [Pol % juice × {(100 – F + 5) ÷ 100}], Where, F= Fibre % cane.

Recoverable sucrose: The recoverable sucrose (%) was calculated by using the following formula:

Recoverable sucrose % = [Pol- {(Brix-Pol) ÷ 100}]× juice factor. Where, juice factor was 0.65 (extraction percentage)

Sugar yield: Sugar yield was calculated using the following formula:Sugar yield (tha^{-1})= [{cane yield (tha^{-1}) × Recoverable sucrose} ÷ 100].

The data was analyzed following standard statistical procedures (Gomez and Gomez, 1984) and mean differences were adjusted by Duncan's New Multiple Range Test (DMRT) using a computer operated program named MSTAT- C.

Results and Discussion

Tiller production: Irrigation levels had significant effect on tiller production at different treatments. Tiller at 90 DAT was 5% level of significantly influenced by irrigation shows in Table 2. The highest tiller production at 90 DAT was recorded in I_2 (I_1 + Irrigation at 21days interval) treatment (112.08 × 10^3 ha^{-1}) followed by I_3 (I_1+ Irrigation at 28 days interval) treatment (106.67 × 10^3 ha^{-1}), while the lowest tiller production at 90 DAT was obtained in I_1 (live irrigation at 0 and 14 days after plantation) treatment (95.67 × 10^3 ha^{-1}). Irrigation level was shown 5% level of significant variation in tiller production at 120 DAT of sugarcane (Table 2). It was seen from the Table 2 that the highest tiller production at 120 DAT was obtained in I_2 (I_1 + Irrigation at 21days interval) treatment (151.67 × 10^3 ha^{-1}) and the lowest in I_4 (I_1+ Irrigation at 35 days interval) treatment (117.29 × 10^3 ha^{-1}). Table 2 showed that the highest tiller production at 150 DAT was obtained in I_2 (I_1 + Irrigation at 21days interval) treatment (233.25 × 10^3 ha^{-1}) and the lowest in I_5 (I_1+ Irrigation at 42 days interval) treatment (162.71 × 10^3 ha^{-1}). Tiller production at 180 DAT was 5% level of significant variation in different irrigation level of plant crop of sugarcane (Table 2). It was seen from the Table 2 that the highest tiller production at 180 DAT was obtained in I_2 (I_1 + Irrigation at 21days interval) treatment (149.38 × 10^3 ha^{-1}) and the lowest in I_5 (I_1+ Irrigation at 42 days interval) treatment (128.71 × 10^3 ha^{-1}). Similar results were obtained by Hossain *et al.* (2009) and Siddique *et al.* (2006).

Table 2. Influence of irrigation on number of tiller, number of mill able cane and cane yield of sugarcane

Treatments	Number of tiller (10^3 ha^{-1}) Days after transplanting (DAT)				Number of millable cane (10^3 ha^{-1})	Cane yield (t ha^{-1})
	90 DAT	120 DAT	150 DAT	180 DAT		
I_1	95.67b	119.38b	173.16b	142.91ab	72.29b	66.64c
I_2	112.08a	151.67a	233.25a	149.38a	106.67a	112.34a
I_3	106.67ab	132.92b	132.17c	142.92bc	96.04a	102.86b
I_4	100.62b	117.29b	175.63b	133.25bc	93.31a	97.53b
I_5	98.33b	121.35b	162.71b	128.71c	88.96ab	93.64b
Level of significance	*	*	**	*	*	**
LSD (0.05)	10.70	18.18	29.33	13.15	17.94	9.26

** Significant at 1% level of probability, * Significant at 5% level of probability, NS = Not significant; I_1: Live irrigation at 0 and 14 days after plantation I_2: I_1 + Irrigation at 21days interval, I_3: I_1+ Irrigation at 28 days interval, I_4: I_1+ Irrigation at 35 days interval , I_5: I_1+ Irrigation at 42 days interval

Millable cane: Different irrigation level was shown at 5% level of significant variation in millable cane production (Table 2). Among the treatments I_2 (I_1 + Irrigation at 21days interval) treatment produced the highest millable cane which was (106.67 × 10^3 ha^{-1}), statistically similar results were obtained in I_3 and I_4 treatments. The lowest millable cane was obtained in I_1 (live irrigation at 0 and 14 days after plantation) treatment in (72.29 × 10^3 ha^{-1}). These results are in agreement with the findings of Siddique *et al.* (2008) and Siddique *et al.* (2006) and Eusufzai *et al.* (2000).

Cane yield: The highest cane yield was recorded in I_2 (I_1 + Irrigation at 21days interval) treatment (112.34 t ha^{-1}) followed by I_3 (I_1+ Irrigation at 28 days interval)

treatment (102.86 t ha^{-1}) which was significantly different 1 % level of significant, while the lowest cane yield was obtained in I_1 (live irrigation at 0 and 14 days after plantation) treatment (66.64 t ha^{-1}) which is shown in Table 2. Similar results was reported by Hossain *et al.* (2009), Siddique *et al.* (2008), Siddique *et al.* (2006) and Eusufzai *et al.* (2000).

Stalk height: Stalk height was significantly variation in different irrigation level which is shown in Table 3. It was also seen from the Table 3 that the highest stalk height was obtained in I_2 (I_1 + Irrigation at 21days interval) treatment (3.16 m) followed I_3 (I_1+ Irrigation at 28 days interval) treatment (3.05m). The lowest stalk height was obtained in I_1 (live irrigation at 0 and 14 days after plantation) treatment (2.78m). These results are in agreement with the findings of Siddique *et al.* (2008), Siddique *et al.* (2006), Eusufzai *et al.* (2000) and Hasan *et al.* (1999).

Table 3. Influence of irrigation on stalk height (m), stalk diameter (cm) and total dry matter of sugarcane

Treatments	Stalk height (m)	Stalk diameter (cm)	Total dry matter (g m^{-2})		
			Days after transplanting (DAT)		
			120 DAT	240 DAT	360 DAT
I_1	2.78e	1.88c	382.63c	2786.36b	3674.64c
I_2	3.16a	2.14a	674.52a	3564.53a	4432.37a
I_3	3.05b	2.12a	498.96b	3828.42a	4236.12ab
I_4	2.95c	2.16a	464.57bc	3608.12a	3949.69ab
I_5	2.93d	1.96b	442.38bc	3066.73b	3867.68bc
Level of significance	**	**	**	**	**
LSD (0.05)	0.0018	0.059	90.66	387.90	512.60

** Significant at 1% level of probability, * Significant at 5% level of probability, NS = Not significant; I_1: Live irrigation at 0 and 14 days after plantation I_2: I_1 + Irrigation at 21days interval, I_3: I_1+ Irrigation at 28 days interval, I_4: I_1+ Irrigation at 35 days interval , I_5: I_1+ Irrigation at 42 days interval

Table 4. Influence of irrigation on juice quality and sugar yield of sugarcane

Treatments	Brix (%)	Pol % juice	Pol % Cane	Purity (%)	Recoverable sucrose (%)	Sugar yield (t ha^{-1})
I_1	16.25c	14.58b	11.45b	89.72a	8.93b	5.95e
I_2	16.85a	14.89a	11.69a	88.36b	9.04a	10.12a
I_3	16.71b	14.24c	11.26c	85.81c	8.55c	7.89b
I_4	16.62b	14.24c	11.18d	85.67d	8.48cd	7.39c
I_5	16.73a	14.21d	11.16e	84.93e	8.41d	6.95d
Level of sig.	**	**	**	**	**	**
LSD (0.05)	0.133	0.0059	0.0059	0.133	0.133	0.0059

** Significant at 1% level of probability, * Significant at 5% level of probability, NS = Not significant; I_1: Live irrigation at 0 and 14 days after plantation I_2: I_1 + Irrigation at 21days interval, I_3: I_1+ Irrigation at 28 days interval, I_4: I_1+ Irrigation at 35 days interval , I_5: I_1+ Irrigation at 42 days interval

Stalk diameter: Influences of different level of irrigation were shown 1% level of significant variation in stalk diameter of sugarcane (Table 3). The highest stalk diameter was obtained in I_2 (I_1 + Irrigation at 21days interval) treatment (2.14cm) and the lowest stalk diameter (1.88cm) was obtained in I_1 (live irrigation at 0 and 14 days after plantation) treatment.

Total dry matter production: In the present investigation significantly different dry matter production were obtained at different growth stages (Table 3). It was observed that the highest dry matter production at 120 DAT of sugarcane was significantly influenced by different level of irrigation treatment. The highest dry matter production was obtained in I_2 (I_1 + Irrigation at 21days interval) treatment (674.52 g m^{-2}) and lowest dry matter production was obtained in I_1 (live irrigation at 0 and 14 days after plantation) treatment (382.63 g m^{-2}). Dry matter production at 240 DAT at 1% level of significance (Table 3). The highest dry matter production of 240 DAT was obtained in I_2 (I_1 + Irrigation at 21days interval) treatment (3564.53 g m^{-2}) and the lowest dry matter production in I_1 (live irrigation at 0 and 14 days after plantation) treatment (2786.36 g m^{-2}). It was also seen from the Table 3 that the highest dry matter production at 360 DAT was recovered in I_2 (I_1 + Irrigation at 21days interval) treatment (4432.37 gm^{-2}) and the lowest was I_1 (live irrigation at 0 and 14 days after plantation) treatment (3674.64 g m^{-2}) and I_2 (I_1 + Irrigation at 21days interval) treatment was superior over other treatments.

Brix (%): Irrigation levels had significant effect on Brix per cent at different treatments which was shown in Table 4. It was seen that the highest Brix (%) was obtained in I_2 (I_1 + Irrigation at 21days interval) treatment (16.85%), statistically similar results in I_3 (I_1+ Irrigation at 28 days interval), while the lowest Brix % was obtained in I_1 (live irrigation at 0 and 14 days after plantation) treatment (17.38%) which was significantly different at 5 % level of significant.

Pol% Juice: Influence of irrigation on pol% juice was found significantly different significance at 1% level of (Table 4). It is seen from the Table 4 that the highest Pol% juice was obtained in I_2 (I_1 + Irrigation at 21days interval) treatment (14.89%) and lowest in I_5 (I_1+ Irrigation at 42 days interval) treatment (14.21%).

Pol% cane: Pol% cane of sugarcane was significantly by influenced different level of irrigation (Table 4). The highest Pol%cane was obtained in I_2 (I_1 + Irrigation at 21days interval) treatment (11.69%) followed by I_1 (live

irrigation at 0 and 14 days after plantation) treatment (11.45%), while the lowest in I_5 (I_1+ Irrigation at 42 days interval) treatment (11.16%). These results are in agreement with the findings of Hossain *et al.* (2009).

Purily (%): The highest purity per cent was recorded in I_1(live irrigation at 0 and 14 days after plantation) treatment (89.72%) and lowest in I_5 (I_1+ Irrigation at 42 days interval) treatment (84.93%) which is shown in Table 4. These results are in agreement with the findings of Jambulingam *et al.* (1999).

Recoverable sucrose: It was observed from the Table 4 that the highest recoverable sucrose was obtained in I_2 (I_1 + Irrigation at 21days interval) treatment (9.04%) and lowest in I_5 (I_1+ Irrigation at 42 days interval) treatment (8.41%) at 1% level of significance. Similar result was reported by Siddique *et al.* (2006) and Eusufzai *et al.* (2000).

Table 5. Economic analysis of sugarcane under different irrigation level

Treatments	Cane yield (t ha^{-1})	Gross return (Tk.ha^{-1})	Total variable cost (Tk.ha^{-1})	Gross margin (Tk.ha^{-1})	Benefit cost ratio (BCR)
I_1	66.64	97294.40	62175.38	35119.02	1.56
I_2	112.34	164016.40	75675.63	88340.77	2.16
I_3	102.86	150175.60	73425.76	76749.84	2.04
I_4	97.53	142393.80	71175.24	71212.56	2.00
I_5	93.64	136714.40	68925.36	67789.04	1.98

Cropping year : 2006-2007, Price of sugarcane : Tk. 1460.00 ton^{-1}, US Dollar ($) 1 = BD. Taka 68.58

Sugar yield: Influence of irrigation on sugar yield was obtained at irrigation which is shown in 5% level of Table 4. The highest sugar yield was obtained in I_2 (I_1 + Irrigation at 21days interval) treatment (10.12 t ha^{-1}) followed by I_3 (I_1+ Irrigation at 28 days interval) treatment (7.89 t ha^{-1}) and while the lowest sugar yield was obtained in I_5 (I_1+ Irrigation at 42 days interval) treatment (6.95 t ha^{-1}). These results are in agreement with the findings of Hossain *et al.* (2009) and Jambulingam *et al.* (1999).

Economic analysis: The cost of production varied among the different level of irrigation treatment which is shown in Table 5. The highest gross return (Tk 164016.40 ha^{-1}) was obtained in I_2 (I_1 + Irrigation at 21days interval) and the lowest gross return (Tk 97294.40 ha^{-1}) obtained from I_1(live irrigation at 0 and 14 days after plantation). The highest total variable cost (Tk 75675.63 ha^{-1}) was obtained in I_2 (I_1 + Irrigation at 21days interval) and the lowest total variable cost (Tk 62175.38 ha^{-1}) was obtained in I_1(live irrigation at 0 and 14 days after plantation). The highest gross margin (Tk 88340.77 ha^{-1}) was obtained in I_2 (I_1 + Irrigation at 21days interval) and lowest gross margin (Tk 35119.02 ha^{-1}) was obtained in I_1(live irrigation at 0 and 14 days after plantation). The highest benefit cost ration (BCR) was obtained in I_2 (I_1 + Irrigation at 21days interval) treatment (2.16) followed by I_3 (I_1+ Irrigation at 28 days interval) treatment (2.04) and the lowest BCR was obtained in I_1 (live irrigation at 0 and 15 days after plantation) treatment (1.56). These results are in accordace with the findings of Hossain *et al.* (1998).

From the experimental findings it can be concluded that the higher cane and sugar yield could be obtained from the I_2 (I_1 + Irrigation at 21 days interval) treatment over any other irrigation treatment level and considering the treatment I_2 farmers will be financially benefited.

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