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Optimization of Irrigation Level for Selected Sugarcane Varieties in AEZ -11 of Bangladesh

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Abstract

An experiment was conducted in a farmer's field at Loknathpur in Chuadanga district under AEZ-11 (high ganges river floodplain) during 2005-06 and 2006-07 to determine the optimum irrigation level for the best performance of four sugarcane varieties (Isd 16, Isd 32, Isd 34, Isd 35). The experiment was laid out in two factors split-plot design with four irrigation levels in main plots and four varieties in sub-plots. Extra irrigations at 21, 28 and 35 days interval in addition to two live irrigations increased sugarcane yield from 15 to 48%. All the varieties showed higher establishment, tiller, millable cane and cane yield when irrigations were applied at 28 days interval over irrigation at 21 or 35 days interval. Variety Isd 32, Isd 34 and Isd 35 produced significantly higher yield. However, the overall performances of all of the selected varieties were satisfactory. These varieties can be cultivated for potential yield in sandy loam soil under AEZ-11 providing 5 irrigations at 28 days interval in addition to two live irrigations at 0 and 14 days after transplantation when soil bed budchip settlings are used as planting materials.

Keywords: Sugarcane, optimization, irrigation, variety.

1. Introduction

Irrigation is a scarce and important input for sugarcane cultivation in Bangladesh. Inadequate or excess water supply is invariably a constraint to growth and yield of sugarcane in the world. For proper plant growth and yield, sugarcane needs about 1260 mm of rain water or equivalent irrigation (Shih *et al*.,1977). In areas of low or unreliable rainfall or where the rainfall is not evenly distributed throughout the year the crop is to be irrigated. Sugarcane has a high water use efficiency than other crops. It has been found that 200-250 tons of water is required to produce one ton of sugarcane (Anon., 1987).

Sugarcane production in Bangladesh suffers fluctuations because of uneven distribution and shortage of rainfall. Yearly rainfall starts from the month of April and continues to October. However, more than 60 percent of the total rainfall concentrates in the month of June, July and August, causing water stagnation in the field. This results oxygen stress in the root zone of sugarcane and loss of yield and reduction of quality. During the rest of the months from November to March, the rainfall is very scanty and erratic (Hossain, 2008). In some of these months there occurs no rainfall at all; whereas plantation, germination and tiller formation of sugarcane mainly take place during these dry months. Sugarcane, thus, in these months needs adequate moisture level to promote successful germination, tillering and growth of the crop. It is reported that yearly 2 to 3 irrigations during November to March increased sugarcane yield by 30% or more (Hossain, 1992). Irrigation required at field condition in the sandy loam soil is about 10 cm (Michael, 1991).

However, excess water use may induce leaching of nutrients beyond root zone and may also create oxygen stress and therefore, may retard growth of plants instead of boosting yield. Sugarcane, in general, grows well up to soil moisture retention range of 0.2 –2.5 bars in arid climates and about 1.8 to 2.5 bars in humid climates. Generally, the percent aeration porosity even after irrigation should not go down below 10% (Husz, 1972 as cited by Srivastava and Singh, 1987).

On the other hand, all varieties of sugarcane do not respond to water stress similarly. Some varieties can withstand more water stress than others and may produce better yield even in drought condition. In contrast, some varieties can produce better yield in water stagnation condition. Besides, a particular variety of sugarcane doesn't show the same performance in the different soil and climatic conditions.

North and north-west regions (AEZ-1, 3, 11 etc.) are the potential areas for sugarcane and almost all the sugar mills are concentrated in these regions. Usually dry climate prevails in this area with low rainfall and high temperature during the summer. Supplementary irrigation may promote yield of sugarcane in this area. An experiment was therefore, conducted at Loknathpur under Chuadanga district (AEZ-11) to determine the optimum irrigation level for the best performance of some selected sugarcane varieties.

2. Materials and Methods

2.1. Location and Treatments

The study was carried out in a farmer's field at Loknathpur under Chuadanga Sub-station of Bangladesh Sugarcane Research Institute (BSRI) in AEZ-11 with four sugarcane varieties viz. Isd 16, Isd 32, Isd 34 and Isd 35 during 2005-06 and 2006-07. Settlings were raised from budchips of these varieties in soil bed. At the age of 42 to 56 days, the settlings were transplanted in the main field. The experiment was laid out in split-plot design with four irrigation treatments in the main plots and four sugarcane varieties in the sub-plots as given in Table1 and was replicated thrice. The plot size of the experiment was 6m x 5m. The soil of the experimental field was sandy loam with P^H value ranged from 6.1 to 7.5. In the sub-plot, budchip settlings were transplanted at a rate of 75 settlings per plot (25000 settlings per hectare).

Fertilizers were applied as per BARC recommendation (BARC, 1989) and intercultural operations were done as per BSRI recommendation (Rahman *et al.*, 1998). The total number of tillers and millable canes produced in each plot were counted and converted into number per hectare. The numbers of tillers produced by different varieties in different irrigation treatments were counted during May 2006 after 6 months of transplantation and the numbers of millable canes were counted just one week before harvesting. Yield of sugarcane was determined during harvesting at the last week of January.

2.2. Irrigation Applied

Number and time of irrigation for different treatments during 2005-06 and 2006-07 are given in Table 2.

Two live irrigations were applied to all treatments at 0 and 14 days after transplantation. From the previous experience it was essential to apply at least two irrigations at 0 and 14 days after transplantation for soil bed settlings (Hossain, 2008). Irrigation treatments I_1, I_2, I_3, and I_4 received a total of 2, 7, 7, and 6 irrigations, respectively. The higher number of irrigations was applied to treatment I_2 and I_3 where irrigation was applied at 21 and 28 days interval. During each of the first two live irrigations, 6 cm water was applied as a sallow irrigation. However, in the latter irrigations, water was applied at a depth of 10 cm each. The depth of water applied was measured by measuring the flow of water in the channel during irrigation.

Table 1. Main plot and sub-plot treatments of the experiment laid in split-plot design.

Main-plot treatment (Irrigation)	Sub-plot treatment (Variety)
I_1 = Life irrigation at 0 and 14 days after plantation	V_1 = Variety Isd 16
I_2 = I_1+ irrigation at 21 days interval	V_2 = Variety Isd 32
I_3 = I_1+ irrigation at 28 days interval	V_3 = Variety Isd 34
I_4 = I_1+ irrigation at 35 days interval	V_4 = Variety Isd 35

Table 2. Number and day of irrigation application for different treatments during 2005-06 and 2006-07 (planted on December 23, 2005 and 2006).

	Treatment			
	I_1 (2 live irrigations)	I_2 (21 days interval)	I_3 (28 days interval)	I_4 (35 days interval)
No. of irrigation	2	2+5 = 7	2+5 = 7	2+4 = 6
Irrigation applied after plantation (DAP)	0,14,	0,14, 35, 56,77,98,119	0,14, 42, 70,98, 126, 154	0,14, 49, 84, 119, 154
Total irrigation water (cm)	12	62	62	52

3. Results and Discussion

3.1. Establishment of settling

Establishment of budchip settlings as influenced by irrigations is shown in Table 3. The highest average establishment was found in treatment I_3 (23.39 x 10^3ha^{-1}) followed by treatment I_4 (23.26 x 10^3ha^{-1}) and I_2 (23.14 x 10^3ha^{-1}) during 2005-06. The lowest average establishment was found in treatment I_1 (22.55 x 10^3ha^{-1}) where no irrigation was applied except two live irrigations.

However, during 2006-07, highest average establishment was found in both I_3 and I_4 (23.72 x 10^3ha^{-1}) followed by I_2 (23.63 x 10^3ha^{-1}). The lowest average establishment was found in I_1 (23.18x10^3ha^{-1}). In I_1 treatment during 2005-06, there was no rainfall in the month of January, February and March while during 2006-07, there was 119 mm rainfall in the month of February and 37 mm in March. So, the average establishment in I_1 (23.18 x10^3ha^{-1}) during 2006-07 was higher than during 2005-06. It is revealed from Table 3 that during both 2005-06 and 2006-07, highest establishment was found in treatment I_3 or I_4 and the lowest was in treatment I_1, which clearly indicates the influence of irrigation on establishment of settlings.

The establishment of settings of different varieties at different irrigation levels is shown in Figure 1 and 2 for 2005-06 and 2006-07, respectively. The differences in establishment of different varieties in different irrigation treatments were not significant. However, the highest establishment of settlings was found in all the varieties under treatment I_3 during 2005-06 (Figure 1). On the other hand, during 2006-07, the highest establishment of settlings was found in varieties V_1 and V_2 under treatment I_3 and $I_{4,}$ while those in varieties V_3 and V_4 under treatment I_2, I_3 and I_4 (Figure 2).

3.2. Number of Tiller

It is evident from Table 3 that during 2005-06 and 2006-07 the average number of tillers produced in treatments I_2, I_3 and I_4 where 5, 5 and 4 extra irrigations were applied, was significantly higher than that of the control treatment I_1, where only two live irrigations were applied. During 2005-06, the highest number of tillers was produced in treatment I_3 (152.30 x $10^3 ha^{-1}$), although the differences were not significant and the lowest number of tillers was produced in treatment I_1 (123.45 x $10^3 ha^{-1}$) (Table 3). Similar effect was also observed during 2006-07 cropping seasons. These evidences have reconfirmed the fact that application of irrigation significantly increases the number of tillers. The same trend of increased tiller with irrigation has been reported by Hossain (2008). Number of tillers also depends on the variety as it is the inherent characteristics. So, at the same input level and environmental condition all varieties did not produce same number of tillers.

Table 3. Effects of irrigation on yield and yield parameters of sugarcane during 2005-06 and 2006-07

Year	Treatment	Establishment of settlings ($x10^3 ha^{-1}$)	Tiller ($x10^3 ha^{-1}$)	Millable cane ($x10^3 ha^{-1}$)	Yield (ton ha^{-1}))
2005-06	I_1	22.55 b	123.45 b	93.73b	76.22 c
	I_2	23.14 a	150.99 a	112.83 a	89.73 b
	I_3	23.39 a	152.30 a	117.56 a	99.62 a
	I_4	23.26 a	148.54 a	115.04 a	97.19 a
	LSD at 5%	0.215	11.37	11.36	5.23
2006-07	I_1	23.18 b	193.38	81.53 b	72.63 b
	I_2	23.63 a	202.68	95.00 a	80.73 a
	I_3	23.72 a	206.89	95.33 a	87.04 a
	I_4	23.72 a	194.91	96.87 a	86.79 a
	LSD at 5%	0.174	ns	9.91	7.56

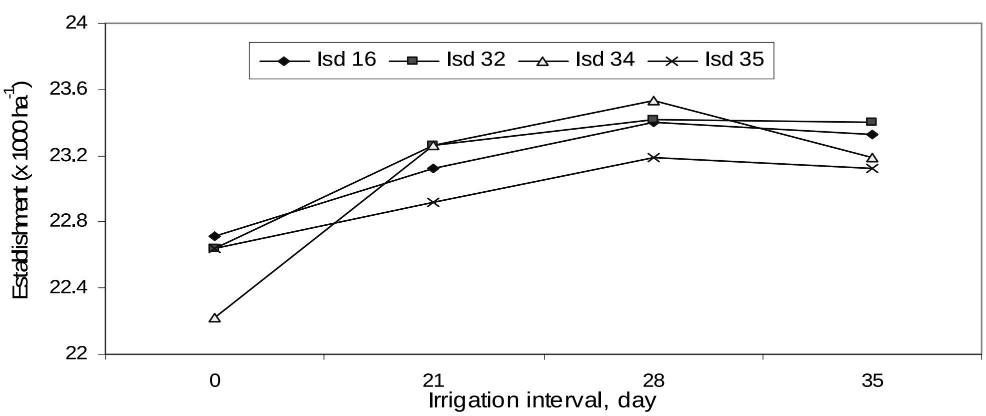

Figure 1. Establishment of settlings at different irrigation levels during 2005-06

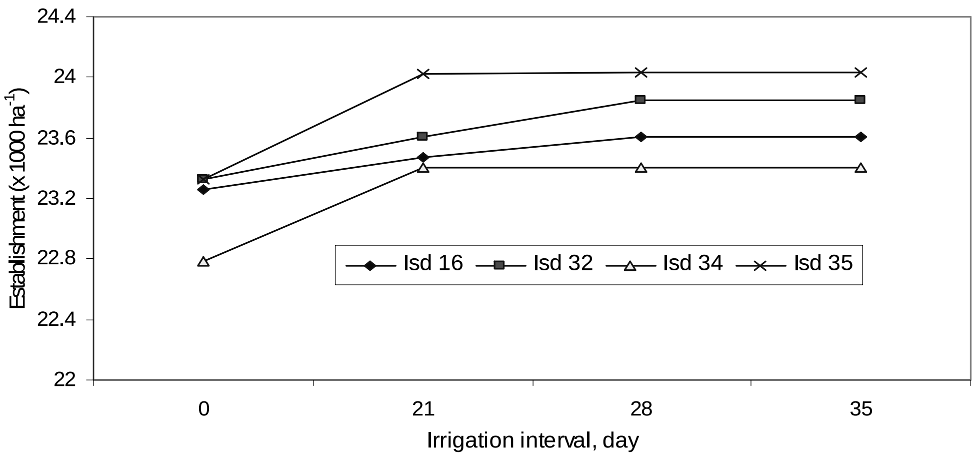

Figure 2. Establishment of settlings at different irrigation levels during 2006-07

The effect of irrigations on tiller production of each of the varieties during 2005-06 and 2006-07 has been shown in Figure 3 and 4, respectively. During 2005-06, the varieties V_1 and V_3 produced the highest number of tillers under treatment I_2. The varieties V_2 and V_4 produced the highest number of tillers under treatment I_3 (Figure 3). However, varieties V_2, V_3 and V_4 showed the best performance under treatment I_3 except V_1 which produced the highest number of tillers under I_2 treatment during 2006-07 (Figure 4). It is evident from both of the results that treatment I_3 is the most responsive treatment for varieties V_2, V_3 and V_4 and treatment I_2 for variety V_1.

3.3. Millable Cane

Millable cane is the number of sugarcane plants that are adequately matured for milling or crushing. The highest average number of millable cane was obtained from the treatment I_3 (117.56 x 10^3ha^{-1}) where irrigation was applied at 28 days interval in addition to two live irrigations at 0 and 14 DAP (Table 3). The lowest average millable canes were obtained from treatment I_1 (93.73 x 10^3ha^{-1}), where only two live irrigations were applied. Similar effects of irrigation were also observed during 2006-07.

The effects of irrigation on millable cane of each variety are shown in Figure 5 and 6 during 2005-06 and 2006-07, respectively. During 2005-06, variety V_1 showed the best performance in I_4 irrigation treatment, varieties V_2 and V_3 in I_3 and variety V_4 in I_2 (Figure 5). However, during 2006-07 cropping season, all the varieties they produced the highest number of millable cane under treatment I_3, where irrigation was applied at 28 days interval in addition to two live irrigations at 0 and 14 DAP (Figure 6).

3.4. Cane Yield

Table 3 shows that irrigation had a positive impact on the yield of sugarcane. During 2005-06 the highest average yield of sugarcane was produced in treatment I_3 (99.62 t ha^{-1}) where irrigation was applied at 28 days interval followed by treatment I_4 (97.19 t ha^{-1}) and I_2 (89.73 t ha^{-1}) while the lowest average yield was in treatment I_1 (76.22 t ha^{-1}). The difference in yield between treatments I_3 and I_4 were statistically insignificant. The average yield obtained from both the cropping seasons showed the same yield trend though there were some yield gaps between the two seasons.

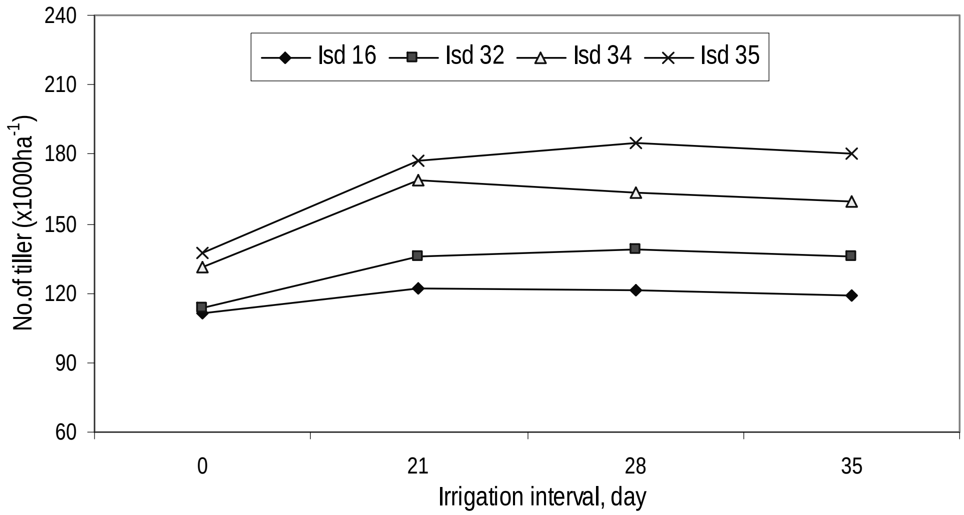

Figure 3. Number of tiller at different irrigation levels during 2005-06.

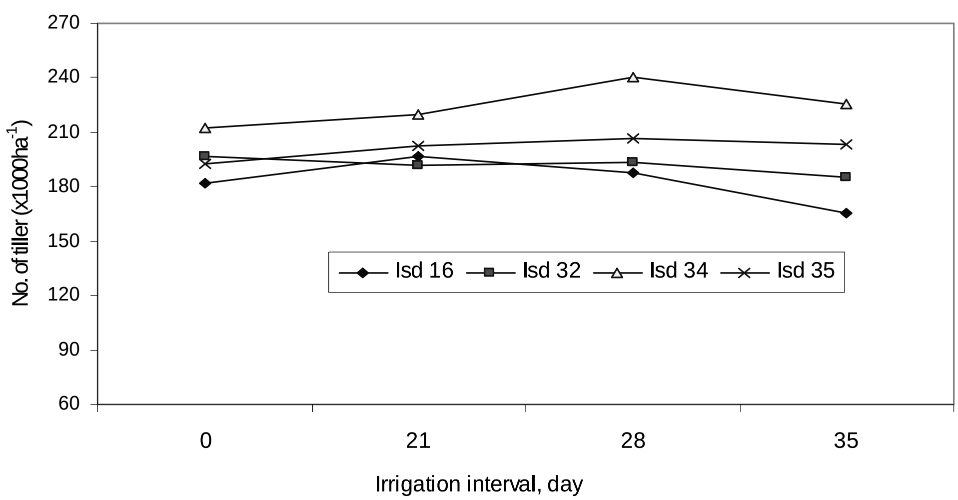

Figure 4. Number of tiller at different irrigation levels during 2006-07

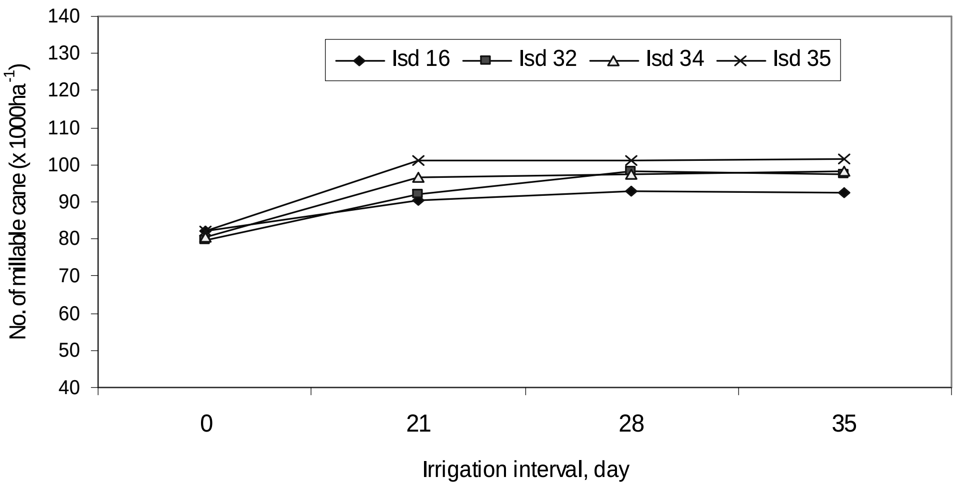

Figure 6. Number of millable cane at different irrigation levels during 2006-07

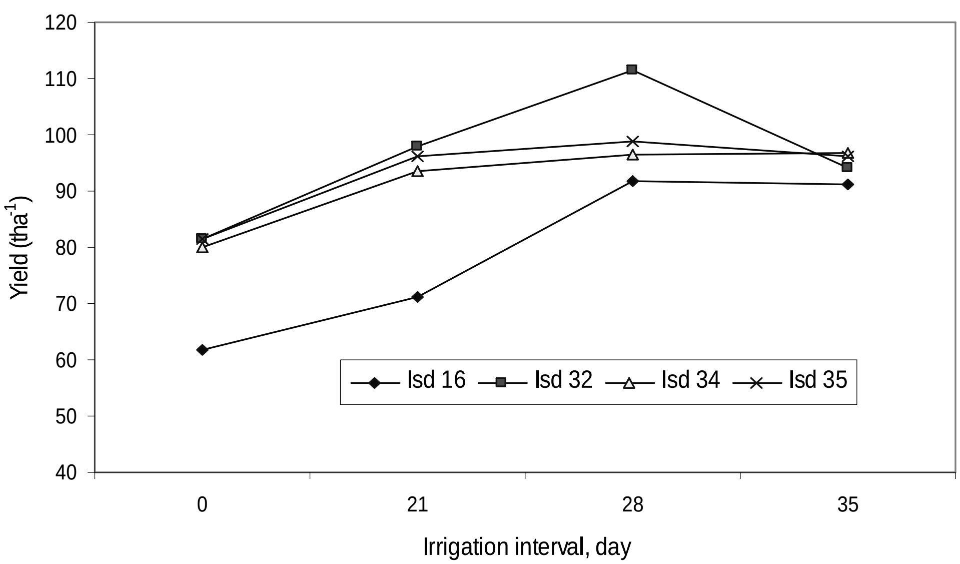

Figure 7. Yield of sgarcane at different irrigation levels during 2005-06

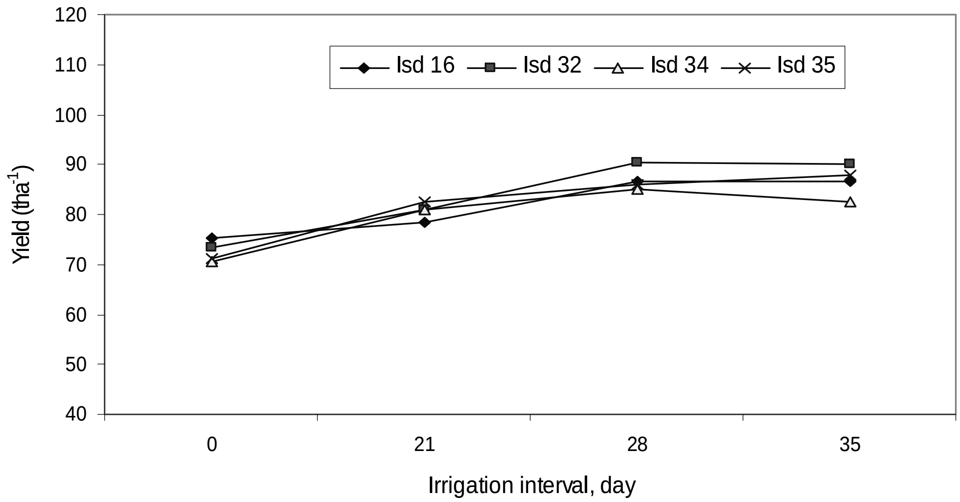

Figure 8. Yield of sugarcane at different irrigation levels during 2006-07

Similar effects of irrigation to increase yield was also found during 2006-07. The highest average yield of sugarcane was also produced in treatment I_3 (86.19 t ha^{-1}), where irrigation was applied at 28 days interval followed by treatment I_4 (86.79 t ha^{-1}) and I_2 (80.73 t ha^{-1}). Rainfalls at the period of growth stages (May-September) of sugarcane much affected the treatments. So, average yield difference among treatments I_2, I_3, and I_4 are statistically insignificant though the treatment I_1 produced significantly lower yield (72. 63 t ha^{-1}) than other treatments. It is important to mention that the average yield in all treatments during 2006-07 were lower than those during 2005-06, because of a remarkable number of plants were lost due to insects and diseases.

Figure 7 and 8 illustrate the effects of different irrigation levels on yield of different varieties during 2005-06 and 2006-07, respectively. Variety V_1 during 2005-06 showed the best yield performance in irrigation treatment I_3 (91.73 t ha^{-1}) (Figure 7).

However, variety V_1 during 2006-07 cropping season showed the best performance in irrigation treatment I_4 (86.76 t ha^{-1}) followed by I_3 (86.63 t ha^{-1}) (Figure 8). Variety V_2 during both the seasons gave the best yield in irrigation treatment I_3, where yields were 111.59 and 90.47 t ha^{-1}, respectively (Figure 7 & Figure 8).

Variety V_3 during 2005-06 cropping season showed the best yield performance in irrigation treatment I_4 (96.74 t ha^{-1}) followed by treatment I_3 (96.49 t ha^{-1}) (Figure 7). During 2006-07, variety V_3 gave the best yield in treatment I_3 (85.13 t ha^{-1}) (Figure 8). Variety V_4 during 2005-06 gave the best yield in treatment I_3 (98.68 tha^{-1}), followed by treatment I_4 (96.07 t ha^{-1}) (Figure 7). However, during 2006-07 cropping season, variety V_4 gave the best yield in irrigation treatment I_4 (87.80 t ha^{-1}), followed by treatment I_3 (85.93 t ha^{-1}) (Figure 8).

3.5. Interaction Effect

The interaction effects of irrigation and variety on establishment of settings, tiller and millable cane production and cane yield during both the cropping seasons were statistically insignificant. Similar results were also reported by Hossain *et al.* (2008) in an experiment conducted at Ishurdi area of Bangladesh. However, variety V_2 showed comparatively better performance (establishment and yield) in all the treatments combinations during both the cropping seasons. In general, I_3V_{1-4} treatment combination produced comparatively higher yield during both the cropping seasons.

4. Conclusions

It appeared that there were significant effects of irrigation on establishment of settlings, production of tiller and millable cane and cane yield of all the varieties. But, there was no evidence of effect of irrigation treatments on individual variety on establishment of settlings, tiller and millable cane production, and cane yield except the control treatment.

All the selected varieties (Isd 16, Isd 32, Isd 34, Isd 35) showed the best and almost similar yield response to irrigation treatments I_3 and I_4. From a conservative point of view, the treatment I_3 where irrigation was applied at 28 days interval in addition to two live irrigations at 0 and 14 days after transplantation **(**DAP) may be recommended as optimum irrigation interval for all the selected varieties.

The selected varieties may be cultivated with potential yield in sandy loam soils of Chuadanga district in AZE-11 by applying 5 irrigations at 28 days interval in addition to two live irrigations at 0 and 10-14 DAP when soil bed budchip settlings are used as planting materials.

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