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Effect of Irrigation on Onion Production

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Abstract: Field experiments were conducted at the Regional Agricultural Research Station, Jessore, Bangladesh; during the rabi seasons (winter) of 1999-2000 and 2000-2001 to compare the yield and yield contributing characters of onion (cv. Faridpuri) under different irrigation schedules. The irrigation sequences were: no irrigation (I_1); irrigation at five days interval (I_2); irrigation at 15 days interval (I_3); irrigation at 20 days interval (I_4) and irrigation at 30 days interval (I_5) up to 30 days before harvesting. Among all the treatments, I_2 produced the highest yields over the years (9.01 and 8.99 t ha^{-1}, respectively). The second highest yields of 8.74 and 8.68 t ha^{-1} were obtained during the two years from the treatment I_3 which received four irrigations at 15 days interval. However, the yields did not show any significant difference with those of I_2. The lowest yields of 3.24 and 3.29 t ha^{-1} were obtained from non-irrigated control plots in the first and second year, respectively. The pooled data of two years revealed that bulb yield was highest (9.0 t ha^{-1}) with irrigation at 10 days interval but was at par with irrigation at 15 days interval. The average bulb yield increase of the irrigated treatments over the control ranged from 97.28% to as high as 175.66%. The estimated total water use of the two highest yielding treatments were 279.5 and 239 mm, respectively. The economic analysis indicates that gross return and net return were highest in I_2 followed by I_3. The marginal rate of return was highest in I_4.The highest marginal gross margin and the second highest marginal rate of return were obtained from I_3. Both of the treatments I_2 and I_3 gave the highest benefit-cost ratio.

Key words: Irrigation, onion bulb, water use efficiency

INTRODUCTION

Onion (*Allium cepa* L.), though mostly used as a spice, also has a good demand as a vegetable. It is extensively used to improve the taste of food and curry. Though among the spices, onion ranks first in respect of area coverage (33,250ha) and production (1,31,090MT), it meets up only about 18%of the national demand. The average national production of onion is only 3.94 t ha^{-1} (Anonymous, 1999) while the world production is about 17 t ha^{-1} (FAO, 1999). The high demand of onion can only be met up by increasing its per hectare yield as there is a very little scope to raise the area due to limitation of cultivable land in Bangladesh. This can be done by a number of ways of which the most important is the judicious application of irrigation water.

Onion can be successfully grown in soils, ranging from sandy loam to clay loam having a pH value of 5.8 to 6.5. For onion cultivation, the day-length is important rather than the age. Mac Gillivery (1961) found that the early onion requires 5 to 7 irrigations and late ones require 7 to 9 irrigations. Doorenbos and Kassam (1979) observed that onion may require irrigation at every 2 to 5 days interval for better yield. Irrigation at 0.40 bar gave much better yield (12.57 t ha^{-1}) than at 0.60 bar (6.6 t ha^{-1}) and at 0.80 bar (5.06 t ha^{-1}) in gray terrace soils of Joydebpur. Applying irrigation throughout the growing season increased the total bulb yield from 52 to 84 t ha^{-1} (Chung, 1989). More frequent irrigation, ranging from 11 to 20 produced higher yield of 17 to 27.4 t ha^{-1}, respectively in the sandy loam soil of India (Singh and Sharma, 1991). Irrigation at 20 days interval up to 60 days produced the best yield in Joydebpur of Bangladesh (Islam *et al*., 1997).

Irrigation based on IW/CPE ratio of 0.7 with 60 mm depth gave 8.0, 24.2 and 164.5% higher bulb yield over 0.9, 0.5 ratios and non-irrigated condition, respectively (Palled *et al*., 1988). But Aujla and Madan (1992) found that higher ratios of IW/CPE ranging from 1.25 to 1.5 produced the higher yield than lower ratios of 0.75 to 1.0. Sadaria *et al*. (1997) reported that irrigation at 1.4 IW/CPE ratio gave the highest bulb yield.

On the basis of the above mentioned studies, it is clear that irrigation schedule for onion vary from region to region. So, it is important to find out a proper irrigation schedule for a particular region that is characterized by its specific soil and climatic condition. The present study was, therefore, aimed to find out a proper irrigation schedule for onion cultivation for the Jessore region in Bangladesh.

MATERIALS AND METHODS

A field experiment was carried out at the Regional Agricultural Research Station, Jessore, during the rabi seasons of 1999-2000 and 2000-2001. The experimental design was randomized complete block (RCB) and replicated thrice. The unit plot size was 3 X 2 m^2. Onion seedlings were transplanted in the plots on 29 December 1999 and 01 January 2001 at the age of six weeks when they attained the height of 10-12 cm. Plant to plant and row to row spacings were 10cm and 20cm, respectively. The soil of the experimental field was silty loam in texture having bulk density of 1.46 g cc^{-1} and field capacity of 27.0% on weight basis.

Following irrigation treatments were used during the study:

I_1 = No irrigation
I_2 = Irrigation at 10 days interval
I_3 = Irrigation at 15 days interval
I_4 = Irrigation at 20 days interval
I_5 = Irrigation at 30 days interval

The plots were fertilized with 90-75-120-18 kg ha^{-1} N, P_2O_5, K_2O and S in the form of urea, triple super phosphate (TSP), murate of potash (MP) and gypsum, respectively. Total amount of TSP and gypsum were applied at the final land preparation. Urea and MP were applied during twotop dressings at 20 DAP and 50 DAP @ one-half each time. Twenty five millimetre of irrigation water were applied immediately after planting to establish the seedlings every year. Soil moisture was measured gravimetrically before each irrigation to find out the amount of irrigation needed to bring the soil moisture to field capacity. It was also determined before transplanting and after harvesting to estimate the actual water consumption. The calculations were done as per the standard formula reported by Michael (1990). Measured amount of water was applied directly into the plots with a bucket of known volume. Irrigation was stopped before 30 days of harvesting. The onion bulbs were harvested on 25 March 2000, in the 1st year and 01 April 2001, in the 2nd year. All necessary data were collected and analyzed statistically. The means were separated by LSD.

RESULTS AND DISCUSSION

The effects of irrigation on bulb yield and yield contributing characters of onion are presented in Table 1. The yield contributing parameters of irrigated plots had significant differences from the untreated control, but non-significant among themselves. In general, plants grown without irrigation were found to be significantly shorter and gave lower number of leaves per plant. The highest yields of 9.01 and 8.99 t ha^{-1} were obtained from I_2 with 6 irrigations at every 10 days interval, in the first and second year, respectively. Statistically similar yields (8.74 and 8.38 t ha^{-1} in the first and second year, respectively) were obtained from treatment I_3 with irrigation at 15 days interval. There was no significant effect of irrigation on percentage of twin bulbs. This result agreed with Chung (1989) and Islam *et al.* (1997).

Table 1: Yield and yield contributing characters of onion as affected by irrigation during 1999-2000 and 2000-2001

Treatments	Plant height (cm)	Leaves/ plant (No.)	Twin bulbs (%)	Bulbs/ kg (No.)	Bulb yield (t ha^{-1})	% yield increased over control
1999-2000						
I_1	37.55	5.22	14.36	109.67	3.24	-
I_2	51.88	10.22	18.50	52.00	9.01	178.08
I_3	51.21	10.02	19.05	53.42	8.74	169.75
I_4	51.16	10.05	19.88	60.67	7.62	135.18
I_5	48.56	9.67	19.07	67.67	6.55	102.16
CV(%)	2.70	5.97	10.66	5.48	8.78	-
LSD(5%)	2.56	1.34	6.20	8.18	1.19	-
2000-2001						
I_1	33.33	7.06	11.29	107.33	3.29	-
I_2	57.00	11.00	17.67	52.67	8.99	173.25
I_3	56.40	10.66	15.33	53.66	8.38	163.82
I_4	55.13	9.93	14.33	59.33	7.79	136.77
I_5	54.33	9.13	12.74	68.67	6.33	92.40
CV(%)	4.49	10.17	16.75	5.86	8.46	-
LSD(5%)	4.35	1.82	6.85	5.28	1.45	-

Table 2: Total water use and water use efficiency during 1999-2000 and 2000-2001

Treatment	No. of irrigation	Total water applied (mm)	Effective rainfall (mm)	Soil water (mm)	Total water use (mm)	Yield (kg ha^{-1})	Water use efficiency (kg ha^{-1} mm^{-1})
1999-2000							
I_1	0	25*	27	65	117	3240	27.69
I_2	6	217	27	35	279	9010	32.29
I_3	4	175	27	34	236	8740	37.03
I_4	3	151	27	40	218	7620	34.95
I_5	2	114	27	47	188	6550	34.84
2000-2001							
I_1	0	25*	38	61	124	3290	26.53
I_2	6	209	38	33	280	8990	32.10
I_3	4	167	38	37	242	8680	35.86
I_4	3	146	38	38	222	7790	35.09
I_5	2	108	38	41	187	6490	34.70

*Twenty five millimeters water was applied for plant establishment in both the years.

Table 3: Combined analysis of yield and yield contributing characters of onion as affected by different level of irrigation 1999-2000 and 2000-2001

Treatment	Irrigation (No.)	Irrigation water (mm)	Total water use (mm)	Plant height (mm)	Leaves/ plant (no.)	Twin bulb (%)	Yield (t ha^{-1})	Water use efficiency (kg ha^{-1} mm^{-1})
I_1	0	25	120.5	35.44	6.14	12.82	3.26	27.05
I_2	6	213	279.5	54.44	10.61	18.08	9.00	32.19
I_3	4	171	239	53.80	10.34	17.19	8.71	36.44
I_4	3	148.5	220	53.14	9.99	17.10	7.70	35.00
I_5	2	111	187.5	51.44	9.40	15.90	6.44	34.77

Table 4a: Benefit-cost analysis of onion (average of 2 years)

Treatment	Bulb yield (t ha^{-1})	Gross return (Tk ha^{-1})	Cost of cultivation (Tk ha^{-1})	Net return (Tk ha^{-1})	Benefit-cost ratio
I_1	3.26	32000	43200	(-)10600	0.74
I_2	9.00	90000	46800	43200	1.92
I_3	8.71	86600	45600	41000	1.91
I_4	7.70	77000	45000	32000	1.71
I_5	6.52	65200	44400	20800	1.46

Table 4b: Marginal analysis of onion as influenced by cost undominated treatments (average of 2 years)

Treatment	Gross return (Tk ha^{-1})	Total variable cost (Tk ha^{-1})	Gross margin (Tk ha^{-1})	Marginal gross margin (Tk ha^{-1})	Marginal variable cost (Tk ha^{-1})	Marginal rate of return (%)
I_2	90000	46800	43200	1700	1200	141
I_3	87100	45600	41500	9500	600	1583
I_4	77000	45000	32000	11200	600	1866
I_5	65200	44400	20800	-	-	-

Tk. = Taka (the official currency of Bangladesh) 1 US$ = Tk. 58.00

Cost of fertilizer /manure (Tk. kg^{-1})			Product price (Tk. kg^{-1})
N	=	13.00	Onion = Tk. 10.00
P_2O_5	=	26.00	
K_2O	=	15.00	
S	=	16.67	
Cowdung	=	0.50	

However, the percentage of twin bulbs was found higher in the treatments receiving more number of irrigations.

The bulbs of irrigated treatments were bigger than those of non-irrigated. Therefore, total number of bulbs per kg weight was larger in case of non–irrigated treatment. Increase in bulb weight under irrigated treatments might be due to growth of taller plants with higher number of leaves causing faster synthesis and translocation of photosynthates from source to sinks.

Irrigation applied, rainfall received, total water use and water use efficiency by the crop are presented in Table 2. In the first year, the total rainfall 27 mm was occurred during the cropping season was effective because each individual rainfall was less than the soil moisture deficit. But following year, the total rainfall was 72 mm and the effective total was 38 mm. Total water use(TWU) varied with the variation of the amount of irrigation water applied to the plots. Maximum TWU was recorded in the treatment I_2 (279 and 280 mm) and the minimum was recorded in I_1(control).Soil water depletion was inversely related to the amount of irrigation water applied. In both the years, water use efficiency (WUE) was the highest for I_3 (37.03 and 35.86 kg ha^{-1} mm^{-1} for both season) and the lowest for I_1 (27.69 and 26.53

kg ha^{-1} mm^{-1}). These result indicate that when onion suffer stress, it efficiency of using water is decreased.

On an average, the highest amount of irrigation water (213 mm) was required in the treatment of irrigation at 10 days interval (I_2). The water use pattern by different treatments was like that as higher the number of irrigations, the less the amount of water needed in each irrigation. This was due to the existence of more moisture in the soil caused by frequent irrigation. Though TWU (average of two years) was the highest (279.5 mm) in treatment I_2 (6 irrigation at 10 days interval) but the highest WUE (36.44 kg ha^{-1} mm^{-1}) was obtained in the treatment I_3 (4 irrigation at 15 days interval) with total water use of 239 mm Table 3. This may be due to that with increased water supply, the increased in evapotranspiration (ET) is proportionately higher than the increase in yield up to a certain limit.

However, the lowest WUE was recorded in untreated control treatment as formation of reproductive structure of sink was not enough to give a better yield due to shortage of water.

Like the trends in year-wise results, the average result of two years (Table 3) also indicates that six irrigation at 10 days interval produce the best bulb yield (9.0 t ha^{-1}) of onion but was at par (8.71 t ha^{-1}) with irrigation at 15 days interval with an average irrigation of 213 and 171 mm, respectively.

Economics: Gross return and net return were highest in treatment I_2 followed by I_3 although benefit-cost ratio was the highest for both I_2 and I_3 (Table 4a). The BCR of 0.74, less than 1.0, in the control treatment indicates the dire necessity of irrigation in onion production. Marginal analysis (Table 4b) shows that treatment I_4 gave the highest (1866%) marginal rate of return (MRR). The second highest (1583%) MRR was obtained from I_3. But the highest yielder I_2 gave the MRR of only 141% due to higher production cost.

From Table 4b, it is revealed that with an additional investment of Tk 600 only, treatment I_3 gave the highest marginal gross margin of Tk 9,500 over I_4 whereas it was only Tk 1700 for treatment I_2 over I_3 with an additional investment of Tk 1200.

From the findings discussed above, it may be concluded that though most of the plant characters including yield have favourably responded with irrigation at 10 days interval but considering the yield per unit water and economics, irrigation at 15 days interval up to 30 days before harvest is the best practice for onion production in Jessore region of Bangladesh.

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