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EFFECT OF IRRIGATION ON THE GROWTH AND YIELD OF (*Daucus carota* ssp. *sativus*) CARROT IN HILL VALLEY

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Abstract

Experiments were conducted at Hill Agricultural Research Station, Khagrachari during the period from November to February in 2005-06 and 2006-07 to determine the appropriate irrigation schedule for carrot production in hill valley. The experiment consisted of five treatments of irrigation after plant established viz. No irrigation (I_0), irrigation at 1W: CPE of 0.6 (I_1), irrigation at 1W: CPE of 0.8 (1_2), irrigation at 1W: CPE of 1.0 (I_3) and irrigation at 1W: CPE of 1.2 (I_4). The amount of irrigation water (IW) was fixed at 4 cm. The experiment was laid out in RCBD with 3 replications. The treatments significantly influenced the growth, yield contributing characters and yield of carrot. Among the treatments, irrigation at IW: CPE of 1.2 gave the maximum yield (51.47 t/ha) which received 4 irrigations after plant stand with applied total irrigation water of 16 cm resulting in the highest net return of Tk. 120,443 with the highest BCR of 2.41. It also produced carrot at the lowest production cost of Tk. 1.66 per kg. Irrigation water use efficiency was obtained 1705.63 kg/ha/cm by this treatment.

Keywords: Irrigation, growth, yield, carrot.

Introduction

Carrot *(Daucus carota* ssp. *sativus)* is a cool-season crop and grown all over the world. It is highly rich in beta-carotene and an excellent source of iron, calcium, phosphorus, and folic acid and also contains good quantities of vitamin B. It is also rich in sugar content (Yawalker, 1992). It has got some important medicinal values (Sadhu, 1993). It is used as salad and as cooked vegetable in soups, stews, curries, etc. and also used for the preparation of pickles, jam, and sweet dishes (Kabir *et al.,* 2000). The popularity of carrot is increasing day by day and very much confined in urban area of Bangladesh.

The cultivation of carrot area is 846 ha and production is 6350 tonnes with an average yield of 7.51 t/ha (BBS, 2005). The low yield occurs due to lack of high yielding varieties as well as the use of non-standard agro-techniques for cultivation. Proper scheduling of irrigation is one of the major factors of agro-techniques for maximizing the yield of carrot. Water is the single important

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factor which directly affects the vegetable yield (Siddiqui, 1995). Water requirement studies for proper irrigation scheduling for carrot have been conducted in a very limited extent in Bangladesh (Islam, 1995). However, information as regards the influence of judicious use of irrigation water for better growth and yield of carrot is lacking in the hilly areas of Bangladesh. Irrigation water scarcity is an acute problem to produce *rabi* crops successfiuily in the hilly areas of Bangladesh. Hence, there is an imperative need for efficient use of the available scarce resource. Keeping in views the above points, the present experiment was undertaken to determine the appropriate irrigation schedule for carrot production in hill valley of Bangladesh.

Materials and Method

This research work relating to determine the appropriate irrigation schedule for carrot production in valley was conducted at Hill Agricultural Research Station, Khagrachari during the period from November to February in 2005-06 and 2006-07. Different moisture regimes were created by different irrigation schedules based on IW: CPE. Five irrigation treatments viz., I_0 = No irrigation after crop stand, I_1 = Irrigation at 1W: CPE of 0.6, I_2= Irrigation at 1W: CPE of 0.8, I_3= Irrigation at IW: CPE of 1.0, I_4= Irrigation at IW: CPE of 1.2 were used in the study. The experiment was laid out in randomized complete block design with three replications. A fixed amount of 4 cm irrigation water was used in the experiment. Pan evaporation data were recorded daily and cumulative figures were calculated subtracting the rainfall. When the ratio between irrigation water (IW) and cumulative pan evaporation (CPE) attained the ratio prefixed for a particular treatment, it was irrigated.

CPE was calculated as follows:

$$I_1=\frac{IW}{CPE}=0.6\Rightarrow\frac{4cm}{CPE}=0.6\Rightarrow CPE=\frac{4cm}{0.6}=6.67cm$$

$$I_2=\frac{IW}{CPE}=0.8\Rightarrow\frac{4cm}{CPE}=0.8\Rightarrow CPE=\frac{4cm}{0.8}=5cm$$

$$I_3=\frac{IW}{CPE}=1.0\Rightarrow\frac{4cm}{CPE}=1.0\Rightarrow CPE=\frac{4cm}{1.0}=4cm$$

$$I_4=\frac{IW}{CPE}=1.2\Rightarrow\frac{4cm}{CPE}=1.2\Rightarrow CPE=\frac{4cm}{1.2}=3.33cm$$

Initially, the crop was irrigated with water-can upto 5 days to ensure germination and a general irrigation of 2 cm was done at 15 days after sowing to ensure good crop stand for all the treatments. The cumulative pan evaporation was calculated from that day for applying treatments. Irrigation use efficiency of carrot was calculated using the following formula for evaluating the contribution of unit amount of water to crop yield.

Irrigation water use efficiency (IWUE) (kg/ha/cm)

$$= \frac{\text{Yield in irrigated plot - yield in control (kg/ha)}}{\text{Irrigation water used (cm)}}$$

The seeds of carrot (cv. New Kuroda) were sown on 14 November 2005 and 10 November 2006. The unit plot size was 2.4 m × 1.2 m and the spacing was 15 cm × 15 cm. Excessive seedlings were thinned remaining healthy one in a hill to maintain proper plant population after 20 days of sowing. All the experimental plots received cowdung @ 10 t/ha, Urea @ 350 kg/ha, TSP @ 250 kg/ha, MoP @ 300 kg/ha and Boric acid 6 kg/ha. The full quantity of cowdung, TSP, Boric acid and 1/4th of Urea and MoP were applied during final land preparation. The rest of Urea and MOP were top dressed in two equal splits at 25 and 50 days after seeding. Intercultural operations were done as and when necessary. The crop was harvested on 28 February 2006 and 22 February 2007, respectively. Ten plants were randomly selected from each plot to record the data on growth and yield contributing characters. The plot yield was converted to yield per hectare. Data were analyzed in the computer package program of MSTAT-C and means were compared by using Least Significant Difference (LSD) at 5% level of significance. Economic analysis was done to work out the most profitable treatment in terms of net returns by taking into account the cost of cultivation and gross return per hectare. The cost of cultivation and gross returns of the crops were calculated on the basis of the local market rates for inputs and outputs. Benefit cost ratio (BCR) was calculated as follows:

BCR = Gross returns (Tk./ha)/Total cost of production (Tk./ha).

Results and Discussion

The results show that all the parameters except leaves per plant were significantly influenced by different irrigation schedules based on 1W and CPE ratio (Table 1, 2 & 3). The highest plant heights (72.73 cm in 2005-06 and 68.63 cm in 2006-07) were recorded in 1_4 that received 4 irrigations at IW/CPE of 1.2 and the lowest

Table 1. Growth and yield attributes of carrot as influenced by irrigation schedule.

Treatments	Plant height (cm)			Leaves/plant (No.)			Individual root wt (g)		
	2005-06	2006-07	Pooled	2005-06	2006-07	Pooled	2005-06	2006-07	Pooled
I_0	53.53	52.00	52.67	10.24	9.97	10.10	104.33	101.20	102.73
I_1	69.40	67.73	68.57	12.10	12.33	12.22	142.33	146.83	144.58
I_2	71.40	68.73	70.07	12.53	12.30	12.42	147.67	142.27	144.97
I_3	70.80	68.00	69.40	11.57	12.47	12.02	150.00	148.60	149.30
I_4	72.73	68.63	70.68	12.50	12.77	12.63	183.00	182.80	182.90
LSD (0.05)	7.30	7.97	7.00	ns	ns	ns	7.46	7.92	4.39
CV (%)	5.74	6.31	5.61	17.46	16.93	16.89	2.72	5.91	4.61

NS= Not significant

I_0=No irrigation after crop stand

I_1= Irrigation at 1W: CPE = 0.6

I_2=Irrigation at 1W: CPE = 0.8

I_3=Irrigation at 1W: CPE = 1.0
I_4=Irrigation at 1W: CPE = 1.2

Table 2. Yield attributes of carrot as influenced by irrigation schedule.

Treatments	Length of root (cm)			Diameter of root (cm)			Dry matter (%)		
	2005-06	2006-07	Pooled	2005-06	2006-07	Pooled	2005-06	2006-07	Pooled
I_0	12.87	12.07	12.47	3.90	3.87	3.88	14.37	13.97	14.17
I_1	13.43	13.10	13.27	4.33	4.37	4.35	12.07	11.70	11.88
I_2	13.87	14.03	13.95	4.57	4.43	4.50	13.03	12.67	12.85
I_3	13.97	14.63	14.30	4.70	4.57	4.63	11.87	11.53	11.70
I_4	14.20	14.43	14.32	4.80	4.67	4.73	10.80	10.47	10.63
LSD (0.05)	ns	2.04	1.64	0.56	0.51	0.53	1.15	1.13	1.12
CV (%)	9.85	7.95	6.37	6.64	6.18	6.33	4.90	4.86	4.84

NS= Not significant
l_0 = No irrigation after crop stand
I_1 = Irrigation at IW: CPE = 0.6
1_2= Irrigation at IW: CPE = 0.8
1_3= Irrigation at IW: CPE = 1.0
1_4= Irrigation at IW: CPE = 1.2

(53.53 cm in 2005-06, 52.00 cm in 2006-07) were recorded in the control treatment (Table 1). Though different irrigation schedules had produced significantly higher plant heights over control, they failed to produce statistical difference among them. Number of leaves per plant did not differ significantly by irrigation treatments. However, the highest number of leaves per plant (12.63 in pooled) was found in 1_4. From the same table, it reveales that individual root weight was significantly influenced by irrigation regimes and maintained a sequence of increase from control to higher water applications (Table 1). The highest individual root weight (183 g in 2005-06) was recorded in treatment 1_4, which was significantly higher over all other treatments. Among the treatments, I_1, 1_2, and 1_3, there was no significant variation of individual root weight. No significant difference in root length was found in 2005-06, but it was found in 2006-07 for both individual year and pooled data (Table 2). The highest length of root (14.32 cm) of pooled data was produced by the treatment 1_4. Root diameter was also found to vary significantly with irrigation. The highest root diameters (4.80 cm in 2005-06 and 4.73 cm in pooled) were found from 1_4 receiving 4 irrigations at IW/CPE of 1.2, but this treatment failed to show superiority over I_1, I_2, and I_3 treatments. Again, I_1 and I_2 treatments did not show significant variation over the control in respect of root diameter. The percentage of dry matter was the highest (14.37 in 2005-06) in control and differed significantly from those of other treatments. The lowest (10.47 in 2006-07) was found in 1_4, which received 4 irrigations at IW/CPE of 1.2. In control treatment, carrot roots received no irrigation water that might have decreased the water content in every cell and

also contributed higher percentage of dry matter. On the contrary, 4 irrigations received by the treatment, IW/CPE of 1.2 supplied frequent water that probably increased water content in every cell, which ultimately contributed higher fresh yield and also decreased the percentage of dry matter. The results are corroborative with the findings of Chowdhury *et al.* (1999). The yield of carrot was also significantly influenced by different irrigation regimes (Table 3). The highest yield (53.80 t/ha in 2005-06) was obtained from treatment 1_4. This treatment showed significantly higher yield over all other treatments. The lowest yield (22.63 t/ha in 2006-07) was recorded in treatment without irrigation. The yield increased in 1_4 by 112.70% in 2005-06 and 111.10% in pooled over those of the control treatment. The highest yield in treatment 1_4 might be due to absorption of ample moisture throughout the growing period that facilitated lower soil strength, greater nutrient uptake and proper physical environment for better root growth and bulking. These increased the volume of root by both in length and diameter and ultimately increased the yield. The result was closely inconformity with the earlier report of Chowdhury *et al.* (1999) and Kabir *et al.* (2000).

Table 3. Yield of carrot as influenced by irrigation schedule.

Treatments	Yield (t/ha)			% yield increase over control		
	2005-06	2006-07	Pooled	*2005-06*	2006-7	Pooled
I_0	25.63	22.63	24.18	-	-	-
I_1	40.33	35.60	37.97	57.70	57.18	57.44
I_2	42.50	40.30	41.40	78.68	65.36	72.02
I_3	45.13	43.80	44.47	86.52	75.45	80.99
I_4	53.80	49.13	51.47	112.70	109.50	111.10
LSD (0.05)	3.49	198	2.25	18.93	1496	16.74
CV (%)	4.46	6.75	3.99	11.29	9.74	5.85

1_0 = No irrigation after crop stand
I_1=Irrigation at 1W: CPE = 0.6
I_2= Irrigation at IW: CPE = 0.8
l_3= Irrigation at IW: CPE = 1.0
I_4= Irrigation at IW: CPE = 1.2

Water use and water use efficiency

Maximum 4 irrigations were given to treatment, IW: CPE of 1.2 and the minimum of 2 to each of 1W: CPE of 0.6 and 0.8 (Table 4). The highest quantity of irrigation water (16 cm) was required in the treatment, IW: CPE of 1.2. Irrigation water use efficiency of carrot varied from 1690.83 to 2152.50 kg/ha/cm with the variation of the amount of irrigation water. The highest irrigation water use efficiency (2152.50 kg/ha/cm) was obtained from the treatment, IW: CPE of 0.8. Chowdhury *et al.* (1999) reported the highest irrigation water use efficiency of 3190 kg/ha/cm by 60% depletion of soil

available water. Similar results were obtained by Islam *et al.* (2006) and Barta and Kallo (1991).

Table 4. Effect of different irrigation schedule on the water use expense by carrot.

Treatments	Yield (t/ha)	No. of irrigations	Days to irrigation	Amount of water/ irrigation (cm)	Total irrigation water (cm)	Irrigation water use efficiency (kg/ha/cm)
I_0	24.18	0	0	0	0	-
I_1	37.97	2	64,90	4	8	1723.75
I_2	414.40	2	56,78	4	8	2152.50
I_3	44.47	3	47,70,87	4	12	1690.83
I_4	51.47	4	42,64,78,90	4	16	1705.63

1_0=No irrigation after crop stand
I_1= Irrigation at IW: CPE = 0.6
l_2= Irrigation at IW: CPE = 0.8
1_3= Irrigation at IW: CPE = 1.0
1_4= Irrigation at IW: CPE = 1.2

Economics

The total cost of production of Tk. 85,447 was found the highest in IW: CPE of 1.2 and the lowest of Tk. 79,278 in control treatment (Table 5). The IW: CPE of 0.6 and IW: CPE of 0.8 incurred the same amount of Tk. 82,362 as these treatments needed equal number of irrigations. The highest gross return of Tk. 205,880 was obtained in IW: CPE of 1.2 and the lowest of Tk. 96,720 in control. The highest net return of Tk. 120,443 with the highest BCR of 2.41 was obtained in IW: CPE of 1.2. One kg carrot was produced by the lowest investment of Tk. 1.66 in the same treatment.

Table 5. Economic analyses of carrot as influenced by different irrigation schedule.

Treatment	Total cost of production (Tk./ha)	Gross return (Tk./ha)	Net return (Tk./ha)	BCR*	Cost/kg produced (Tk.)
I_0	79,278	96,720	17,442	1.22	3.28
I_1	82,362	151,880	69,518	1.84	2.17
I_2	82,362	165,600	83,238	2.01	1.99
I_3	83,905	177,880	93,975	2.12	1.89
I_4	85,447	205,880	120,443	2.41	1.66

*BCR= Benefit cost ratio
I_0= No irrigation after crop stand
I_1Irrigation at 1W: CPE= 0.6
I_2=irrigation at 1W: CPE= 0.8
I_3=Irrigation at 1W: CPE= 1.0
I_4=Irrigation at 1W: CPE= 1.2
Considering local market price of 2007,

Labour cost Tk. 120 man-day^{-1}, irrigation cost =Tk. 1000 ha^{-1}irrigation^{-1}
Urea, TSP, MoP and cowdung @Tk 7, 16, 16/kg and 700/t, respectively.
Carrot sale **@** Tk. 4/kg (Farm gate price)

Conclusion

From the above discussion, it could be concluded that 4 irrigations after plant stand at an interval of 20-25 days in December to mid January and 12-15 days in the rest of the growing period of the crop in hill valley of Bangladesh may be recommended for better growth and economic yield of carrot.

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