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EFFECT OF NUMBER OF PLANT PER HILL AND IRRIGATION INTERVALS ON THE GROWTH AND YIELD OF CARROT (*Daucus carota* L.)

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ABSTRACT

A field experiment was conducted at the Horticultural Farm in Hajee Mohammad Danesh Science and Technology University, Dinajpur, during the period from November, 2013 to February 2014 to evaluate the effect of number of plant per hill and irrigation intervals on the growth and yield of carrot. There were three levels of number of plant per hill viz. 1, 2 and 3 plants per hill and four irrigation intervals (I_0 = No irrigation after germination, I_1 = 14 days, I_2 = 21 days, and I_3= 28 days) in the study. The treatments were replicated three times and laid out in a randomized complete block design (RCBD). Number of plant per hill as well as the intervals of irrigation and their interaction significantly influenced the growth and yield of carrot. Yield increased with the increase in number of plants per hill. Three plants per hill produced highest total and marketable yields of roots (24.75 and 21.12 t/ha, respectively), while single plant per hill produced the lowest yields of roots (11.42 and 9.5 t/ha, respectively). It was observed that irrigation interval at 21 days interval had produced the highest total and marketable yields of roots (22.4 and 19.2 t/ha, respectively), while no irrigation produced the lowest total and marketable yield of roots (14.8 and 11.5 t/ha, respectively). The highest total and marketable yields (33.0 and 25.33 t/ha, respectively) were found in the treatment combination of three plants per hill with irrigation scheduling at 21 days interval, which also gave the best economic return (TK. 40160/ha) and the highest benefit cost ratio (4.90).

Key words: Carrot, growth, irrigation, yield

INTRODUCTION

Carrot (*Daucus carota* L.) is a cool season crop and is grown all over the world (Alam *et al*. 2010). It is highly rich in beta-carotene and an excellent source of iron, calcium, phosphorus, vitamin B, sugar and folic acid. It also has some medicinal values in the production of vitamin A (Sadhu 1993). It is used as salad and cooked vegetable in soups, stews, curries, preparation of jams, pickles, and sweet dishes (Kabir *et al*. 2000). Cultivation of carrot becomes more popular day by day to the farmers of Bangladesh. In the year 2009-2010, the area under carrot cultivation was 1,215 hectares, total production of 14,000 metric tons in Bangladesh (BBS, 2010). Yields are too low due to lack of high yielding varieties as well as the use of low standard agro-technologies (Kabir *et al*. 2000). Production of carrot in Bangladesh could be increased in two ways, either by extending the area for cultivation and by increasing yield per hectare. However, increasing the area is not possible due to land limitation in Bangladesh. Only way that remains to increase the production of carrot is to increase per hectare yield. Growers generally allow growing single carrot plant per hill. Planting more than one plant per hill can increase the production, as reported in case of carrot and sweet potato (Siddique and Rabbani 1987). Planting more than one plant per hill has been shown to give higher yield of carrot (Islam *et al.* 2006; Tarafder 1999). Proper irrigation scheduling has been observed as one of the major factors of agro-technologies for increasing the yield of carrot (Barta and Kallo, 1991). Water is the single most important factor that directly influences the yield of vegetables (Siddiqui 1995).

Water requirement studies of carrot for proper irrigation scheduling have been conducted in Nigeria but to a limited extent (Islam, 1995 and Islam *et al*., 2006). However, information regarding the efficient use of irrigation water for improved growth and higher yield of carrot is still lacking in Bangladesh. Scarcity of irrigation water is an acute problem for successful crop production anywhere in the world (Chowdhury *et al*. 1999). Hence, there is an

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imperative need for efficient use of the scarce irrigation water for high quality carrot production. Considering above facts, the present study was undertaken to maximize the yield of carrot through planting more than one plant per hill and the appropriate irrigation interval for carrot production in Bangladesh.

MATERIALS AND METHODS

The present experiment dealing with the effect of number of plant per hill and irrigation intervals on the growth and yield of carrot was conducted at the field laboratory of Department of Horticulture, Hajee Mohammad Danesh Science and Technology University, Dinajpur during November 2013 to February 2014. The carrot cultivar New Kuroda was used in this experiment. Seeds were sown on 19 November, 2013. The experiment was consisted of two factors each of which had three levels of number of plant per hill viz. 1, 2 and 3 plants per hill and four irrigation intervals (I_0 = No irrigation after germination, I_1 = 14 days, I_2 = 21 days, and I_3= 28 days) in the study. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The size of each plot was 1.5m × 1m. 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. Necessary intercultural operations as well as pest management were done whenever necessary. The crop was harvested depending upon the attaining of good sized root. The data were collected from the 10 randomly selected plants from inner rows for each treatment. The percent dry matter in modified root and leaves was calculated by using following formula:

$$\%Dry\ matter = \frac{Dry\ matter}{Fresh\ weight} \times 100$$

The mean values of all the characters were evaluated and analysis of variance was performed by the LSD test. 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:

$$Benefit\ cost\ ratio(BCR) = \frac{Gross\ return\ per\ hectare\ (Tk.)}{Total\ cost\ of\ production\ per\ hectare\ (Tk.)}$$

RESULT AND DISCUSSION

Plant height: A statistically significant variation was recorded in terms plant height due to the number of plant per hill of carrot under the present trial (Table 1). In the present trial single plant grown per hill (P_1) gave the tallest plant (32.09cm), while the shortest plant (29.02cm) was observed from two plants per hill (P_2). Different irrigation intervals showed significant difference of plant height (Table 2). The tallest plant (33.49 cm) was observed from at 28 days interval (I_3), while no irrigation (I_0) produced the shortest plant (25.39 cm). Interaction effect of number of plant per hill and different irrigation intervals showed significant variation of plant height (Table 3). The tallest plant (35.75 cm) was recorded from the combination of P_1I_3 (single plant per hill and irrigation interval at 28 days). On the other hand P_2I_0 (two plants per hill with no irrigation) gave the shortest plant (24.4cm).

Length of root: Root length showed statistically significant differences for plant per hill (Table 1). Single plant per hill (P_1) gave the longest (14.03cm) root; on the other hand the three plants per hill gave the shortest (11.19 cm) root. Root length showed statistically significant variation for different irrigation intervals under the trial (Table 2). The longest root (13.47 cm) was recorded from the irrigation interval of 21 days (I_2), while no irrigation produced the lowest (10.39 cm). Interaction effect between plant per hill and different irrigation interval showed statistically significant variation under the present trial in respect of root length (Table 3). The longest root (15.20 cm) was recorded from the combination of P_1I_1 (Single plant per hill and irrigation interval at 14 days) and P_3I_0 (Three plants per hill and no irrigation) gave the shortest root (9.22 cm) (Table 3). Islam *et al*. (2006) reported the same results. The longest root (13.69 cm) was obtained by single plant per hill whereas shortest root was (11.69 cm) obtained by three plants per hill.

Fresh weight of root: A statistically significant variation was recorded in terms of fresh weight of root due to the number of plant per hill of carrot under the present trial (Table 1). Maximum fresh weight of root per plant (79.53 g) was obtained when single plant (P_1) was grown per hill while the minimum (55.36 g) was observed when two plants (P_2) were grown per hill. Different irrigation intervals showed significant differences in terms of fresh root weight (Table 2). The maximum fresh weight of root

Table 1. Effect of number of plant per hill on the growth and yield of carrot

Treatment	Plant height (cm)	No. of leaves /plant	Individual fresh wt. of root (g)	Length of root (cm)	Diameter of root	Dry matter (%)	Total Yield (t/ha)	Marketable Yield (t/ha)
P_1	32.09 a	12.85 a	79.53 a	14.03 a	3.405 a	11.72 a	11.42 c	9.50 c
P_2	29.02 b	10.40 b	55.36 b	12.00 b	3.047 b	11.90 a	16.38 b	14.30 b
P_3	29.49 b	9.583 b	58.89 b	11.19 c	2.850 b	12.09 a	24.75 a	21.12 a
Lsd (0.05%)	1.308	0.9378	16.07	0.4567	0.2142	0.4284	3.612	1.491

P_1=One Plant per hill, P_2= Two Plants per hill and P_3= Three plants per hill

Table 2. Effect of irrigation on the growth and yield of carrot

Treatment	Plant height (cm)	No. of leaves /plant	Individual fresh wt. of root(g)	Length of root (cm)	Diameter of root	Dry matter (%)	Total Yield (t/ha)	Marketable Yield (t/ha)
I_0	25.39 c	10.08 b	49.13 c	10.39 c	2.568 b	11.23 b	14.8 b	11.5 c
I_1	29.79 b	11.06 ab	57.32 bc	13.32 a	3.181 a	12.14 a	14.9 b	14.6 b
I_2	32.12 a	11.32 a	77.57 a	13.47 a	3.307 a	12.37 a	22.4 a	19.2 a
I_3	33.49 a	11.32 a	74.36 ab	12.45b	3.347 a	11.87 a	17.8 b	14.6 b
Lsd (0.05%)	1.51	1.083	18.55	0.5274	0.2473	0.4946	4.171	1.721

I_0 = No irrigation after germination, I_1 = Irrigation at14 days interval, I_2 = Irrigation at 21 days interval, and I_3= Irrigation 28 days interval

(77.57 g) was recorded from irrigation interval of 21 days (I_2) which was closely followed by (74.36 g) with irrigation interval at 28 days and the minimum fresh weight (49.13 g) of root per plant was recorded from I_0 as no irrigation after germination. Interaction effect of plant per hill and different irrigation interval performed statistically significant differences under the present trial (Table 3). The maximum fresh weight of root (97.65 g) per plant was recorded from the combination of P_1I_3 (Single plant per hill and irrigation interval at 28 days). On the other hand P_3I_0 (three plants per hill with no irrigation) gave the minimum fresh weight of root (35.11 g) (Table 3). Islam *et al*. (2006) reported similar result with the present study. This observation corresponded with previous research reports by Hamma *et al*. (2012), who reported that irrigation at 5 days interval and 250 kg NPK ha^{-1} received adequate supply of water and fertilizer which probably increased water content of every cell, and ultimately contributed to higher fresh root yield per plant.

Diameter of root: A statistically significant difference was recorded due to the number of plant per hill of carrot in terms of diameter of root (Table 1). Single plant per hill (P_1) gave the maximum diameter of root (3.40 cm). Again three plants per hill (P_3) gave the minimum diameter of root (2.85 cm). Different irrigation interval showed statistically significant variation in terms of diameter of root (Table 2). The maximum diameter of root (3.34 cm) was recorded from irrigation interval at 28 days as I_3 which was closely followed (3.30 cm and 3.18 cm) by I_2 and I_1 as irrigation interval at 21and 14 days, respectively and the minimum diameter of root (2.56 cm) was recorded from I_0 as without irrigation. Interaction effect between number of plant per hill and application of different intervals of irrigation showed statistically significant variation under the present trial in respect of diameter of root (table 3). The maximum diameter of root (4.00 cm) was recorded from the combination of P_1I_3 (Single plant per hill and irrigation interval at 28 days) and P_3I_0 (single plants per hill with no irrigation) gave the minimum diameter of root (2.30 cm). The result of this experiment are in supported of the findings of Alam *et al.* (2010) who reported that the highest root diameters (4.80 cm) was found from 4 irrigations at IW/CPE (Irrigation water/Cumulative Pan Evaporator) of 1.2.

No. of leaves/plant: Number of leaves per plant showed a statistically significant variation due to the number of plant per hill of carrot (Table 1). In the present trial single plant per hill (P_1) gave the maximum number of leaves per plant (12.85), on the other hand the three plants per hill (p_3) gave the minimum number of leaves per plant (9.58). The application of different intervals of irrigation of carrot showed significant variations in terms of number of leaves per plant (Table 2). The maximum number of leaves per plant (11.32) was recorded from irrigation interval at 21 and 28 days of I_2 and I_3 which was closely followed (11.06) with I_1 and the

minimum (10.08) number of leaves per plant was recorded from I_0 as without irrigation. Interaction effect between the number of plant per hill and the application of different intervals of irrigation showed statistically significant variation in terms of number of leaves per plant (Table 3). The maximum number of leaves per plant (14.33) was recorded from the combination of P_1I_3 (Single plant per hill and irrigation interval at 28 days) and P_3I_0 gave the minimum number of leaves per plant (8.927).

Dry matter (%): Percent dry matter was not statistically significant for the number of plant per hill (Table 1). Three plants per hill (P_3) gave the highest dry matter content (12.09%); on the other hand two plants per hill (P_1) gave the lowest dry matter content (11.72%). Dry matter showed statistically significant variation for the application of different intervals of irrigation of carrot (Table 2). The highest dry matter content (12.37%) was recorded from irrigation interval at 21 days which was statistically similar (12.14% and11.87%) with irrigation interval at 14 days and irrigation interval at 28 days , respectively and the lowest dry matter content (11.23 %) was recorded in I_0 as without irrigation. Interaction effect between the number of plant per hill and the application of different intervals of irrigation showed statistically significant variation under the present trial in respect of dry matter content of root (Table 3). The highest dry matter content (12.85%) of modified root was recorded from the combination of P_3I_2 (three plant per hill and irrigation interval at 21 days) and P_1I_1 (single plant per hill and irrigation interval at 14 days)

Table 3. Combined effect of number of plant per hill and irrigation on the growth and yield of carrot

Treat-ment	Plant height (cm)	No. of leaves /plant	Individual fresh wt. of root(g)	Length of root (cm)	Diameter of root	Dry matter (%)	Total Yield (t/ha)	Marketable Yield (t/ha)
P_1I_0	25.31ef	11.21 cd	68.97abcd	11.99d	2.670 ef	12.22 abcd	8.7 f	7.00 f
P_1I_1	30.20 cd	12.20 bc	64.90 abcd	15.20 a	3.333 bc	9.993 f	11.0 ef	10.33 de
P_1I_2	30.73 c	13.67 ab	86.60 ab	14.68ab	3.613 ab	12.43 abcd	12.0 def	9.00 ef
P_1I_3	35.75 a	14.33 a	97.65 a	14.23 b	4.003 a	12.23 abcd	14.0 cdef	11.67de
P_2I_0	24.40 f	10.10 cde	43.32 cd	9.957 f	2.733 def	12.66 ab	14.2 cdef	11.83 de
P_2I_1	27.69 de	10.70 cde	49.63 bcd	12.85cd	3.090cde	11.20 e	14.0 cdef	11.50 de
P_2I_2	31.00 c	10.34 cde	66.45abcd	13.10 c	3.197bcd	11.83 bcde	17.0bcde	13.33 cd
P_2I_3	32.98 bc	10.48 cde	62.05 abcd	12.10cd	3.167bcd	11.90 a-e	20.3 bc	20.67 b
P_3I_0	26.47ef	8.927 e	35.11 d	9.220 f	2.300 f	11.53 cde	21.7 bc	15.67 c
P_3I_1	31.49 c	10.29 cde	57.43 bcd	12.36cd	3.120cde	12.49 abc	19.8 bcd	22.00 b
P_3I_2	34.63 ab	9.960 de	70.03 abcd	12.17cd	3.110cde	12.85 a	33.0 a	25.33 a
P_3I_3	31.73 c	9.157 de	73.01 abc	11.02 e	2.870cde	11.47 de	24.5 b	21.50 b
Lsd	2.615	1.876	32.13	0.9134	0.4284	0.8586	7.224	2.981

P_1=1 Plant per hill, P_2= 2 Plants per hill and P_3= 3 plants per hill, I_0 = No irrigation after germination, I_1 = Irrigation at14 days interval, I_2 = Irrigation at 21 days interval, and I_3= Irrigation 28 days interval

gave the minimum dry matter content (9.99%). The result of the present study is in full agreement with the findings of Islam *et al.* (2006).

Total yield (t/ha): A statistically significant difference was recorded in terms of yield per hectare for the application of different intervals of irrigation in carrot (Table 1). Three plants per hill (P_3) gave the highest yield per hectare (24.75 t); on the other hand single plant per hill gave the lowest yield per hectare (11.42 t). Yield per hectare showed statistically significant variation for the application of different intervals of irrigation under the trial (Table 2). The highest yield per hectare (22.4 t) was recorded from irrigation interval at 21 days (I_2) and the lowest yield per hectare (14.8 t) was recorded from I_0 as without irrigation which was statistically identical (14.9 t and 17.8 t) by I_1 and I_3 as the application of irrigation interval at 14 days and 28 days. Interaction effect between the number of plant per hill and the application of different intervals of irrigation showed statistically significant variation under the present trial in respect of yield per hectare (Table 3). The highest yield per hectare (33.0 t) was recorded from the combination of P_3I_2 (three plants per hill and irrigation interval at 21 days) and P_1I_0 (single plant per hill and no irrigation) gave the lowest total yield per hectare (8.7kg). Islam *et al.* (2006) also reported that the yield increased with the increase in number of plants per hill. Three plants per hill produced the highest total yield of carrot (52.16 t/ha) and single plant per hill produced lowest (40.59 t/ha). The result was closely conformity with the earlier report of Alam *et al.* (2010) who reported that the highest yield in treatment irrigation at 1W: CPE of 1.2 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 of the present study is in agreements with the findings of Kabir *et al*. (2000) who showed that Irrigation interval at 5 days and NPK fertilizer 250 kg ha-1 significantly produced higher treatment means because of adequate supply of water and nutrition which enhanced the process of photosynthesis consequently more partitioning of assimilates were recorded.

Marketable Yield (t/ha): A statistically significant difference was recorded for the number of plant per hill of carrot in terms of marketable yield per hectare (Table 1). Three plants per hill (P_3) gave the highest marketable yield per hectare (21.12 t); on the other hand the single plant per hill gave the lowest marketable yield per hectare (9.50 t). Marketable yield per hectare showed statistically significant variation for the application of different intervals of irrigation under the trial (Table 2). The highest marketable yield of root per hectare (19.2 t) was recorded from irrigation interval at 21 days (I_2) which was closely followed (14.6 t) by I_1 (irrigation interval at 14 days) and I_3 (irrigation interval at 28 days), and the lowest marketable yield per hectare (11.5 t) was recorded from I_0 as without irrigation. Interaction effect between the number of plant per hill and the application of different intervals of irrigation showed statistically significant variation under the present trial in respect of marketable yield of root per hectare (Table 3). The highest marketable yield per hectare (25.33 t) was recorded from the combination of P_3I_2 (three plants per hill and irrigation interval at 21 days) and P_1I_0 (single plant per hill and no irrigation) gave the minimum marketable yield per hectare (7.00 t) (Table 3). Islam *et al.* (2006) reported similar result that the highest marketable yields of carrot (46.83 t/ha) was obtained when three plants were grown per hill while the lowest yield (38.23 t/ha) was recorded at one plant per hill.

Economic analysis: In the combination of the number of plant per hill and the application of different intervals of irrigation showed different gross return (Table 4). The highest gross return was (Tk. 379,950) obtained from P_3I_2 (three plants per hill and irrigation interval at 21 days) and the lowest gross return (Tk. 105,000) was obtained in the P_1I_0 (single plant per hill and no irrigation). In case of net return different treatment combination showed different types of net return (Table 4). The highest net return (Tk. 302,484) was obtained from P_3I_2 (three plants per hill and irrigation interval at 21 days) and the lowest net return (Tk. 40,160) was obtained in the P_1I_0 (single plant per hill and no irrigation). The highest benefit cost ratio (4.90) was attained from P_3I_2 (three plants per hill and irrigation interval at 21 days). The lowest benefit cost ratio (1.61) was obtained from P_1I_0 (single plant per hill and no irrigation) (Table 4). From economic point of view, it is apparent from the above results that three plants per hill and irrigation interval at 14 (P_3I_1) days were the best combination for carrot cultivation in the present trial. A similar finding is supported by Alom *et al*. 2010 and reported that irrigation at IW: CPE of 1.2 gave the highest net return of Tk. 120,443/ha with the highest BCR of 2.41. It also produced carrot at the lowest production cost of Tk. 1.66 per kg.

Table 4. Cost and return of carrot cultivation as influenced by plant per hill and irrigation intervals

Treatment combination	Marketable yield (t/ha)	Total cost of production (Tk/ha)	Gross return (Tk/ha)	Net return (Tk/ha)	Benefit cost ratio (BCR $=\frac{GI}{TCP}$)
P_1I_0	7.00	64840	105000	40160	1.61
P_1I_1	10.33	65430	154950	89520	2.36
P_1I_2	9.00	66020	135000	68980	2.04
P_1I_3	11.67	66610	175050	108440	2.62
P_2I_0	11.83	71212	177450	106238	2.49
P_2I_1	11.50	71802	172500	100698	2.40
P_2I_2	13.33	72392	199950	127558	2.76
P_2I_3	20.67	72982	310050	237068	4.24
P_3I_0	15.67	76286	235050	158764	3.08
P_3I_1	22.00	76876	330000	253124	4.29
P_3I_2	25.33	77466	379950	302484	4.90
P_3I_3	21.50	78056	322500	24444	4.13

Irrigation water use efficiency was obtained 1705.63 kg/ha/cm by this treatment.

I USD= Tk.80 approximately
Market price of carrot@ Tk 15000/ton
Gross return= Total price (t/ha) ×Tk 15000
Net return= Gross return- Total cost of production
Benefit: Cost= Gross return/ Total cost of production

CONCLUSION

From the above discussion, it could be concluded that three plants per hill with irrigation at 21 days interval may be recommended for better growth and economic yield of carrot in Dinajpur due to their superior performances.

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