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Growth and yield of carrot influenced by organic and inorganic fertilizers with irrigation interval

Annisha Afrin, M. Ashraful Islam✉, Md. Mokter Hossain, Md. Mehedi Hasan Hafiz

Department of Horticulture, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh

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Correspondence:
M. Ashraful Islam
✉: ashrafulmi@bau.edu.bd

ABSTRACT

The experiment was carried out at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh to investigate the influence of organic and inorganic fertilizers with irrigation intervals on the growth and yield of carrot during November, 2016 to March, 2017. Different days interval irrigation were applied namely no irrigation (I_0), 7 days interval (I_7), 15 days interval (I_{15}) and 30 days interval (I_{30}). Organic and inorganic fertilizers were given as treatments like control (no fertilizer) (F_0), vermicompost (F_1), mixed fertilizer (2/3 vermicompost + 1/3 inorganic fertilizer) (F_2), inorganic fertilizer (F_3). The experiment was laid out in RCBD (randomized complete block design) with three replications. Irrigation interval treatments showed significant influence on growth and yield related parameters of carrot. Plant height, other growth related parameters and yield were found significantly different considering the effect of irrigation and fertilizers treatments. Considering the effect of irrigation, the highest and the lowest plant height was obtained 45.35 cm and 39.77 cm from 7 days interval irrigation and control, respectively. The highest marketable yield (42.47 t/ha) was found from 7 days irrigation interval and it was 27.40% higher compared to control (30.83 t/ha). Mixed of organic and inorganic fertilizer (F_2) gave the highest plant height (47.58 cm) and the lowest plant height (35.08 cm) was found from the control treatment. Gross yield and marketable yield per hectare were higher 21.21% and 22.03% in F_2 compared to control treatment. Considering the treatment combination, irrigation at 7 days interval with mixed fertilizer (I_7F_2) produced the highest plant height (50.42 cm), number of leaves (11.67), diameter of root (3.90 cm), length of root (23.20 cm), fresh weight of individual root (106.20 g), gross yield (53.66 t/ha) and marketable yield (46.91 t/ha). The lowest plant height (32.75 cm), number of leaves (7.83), diameter of root (3.10 cm), length of root (13.00 cm), fresh weight of individual root (65.00 g), gross yield (32.00 t/ha) and marketable yield (26.72 t/ha) were found from the treatment combination of no irrigation with no fertilizer (I_0F_0). Gross yield and marketable yield per hectare were 40.37% and 43.04% higher, respectively in irrigation at 7 days interval with mixed fertilizer than other treatments combination. Irrigation interval at 7 days with mixed fertilizer had the most positive effect for the production of carrot.

Introduction

Carrot *(Daucus carota* L.*)* is an important short duration root vegetable. It contains appreciable amount of carotene, thiamin, riboflavin, iron, calcium and phosphorus. 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). In the year 2015-2016, the area under carrot cultivation was 1768 ha and total production was 15679 metric tons in Bangladesh (BBS, 2016), but yield is relatively low in our country as compared to other carrot producing countries due to lack of agro-technical knowledge about irrigation interval and judicial application of fertilizer for crop production. Fertilizer application i.e. soil management activities has become a major part of farming practice to improve the soil fertility (Zuazo and Pleguezuelo, 2008). Organic agriculture is gaining worldwide attention and focusing for reduction and elimination of the adverse effects of synthetic fertilizers and pesticides on human health and the environment. In recent years, use of organic manure or vermicompost has been advocated in integrated nutrient management (INM) system in vegetable crops. Organic manure is becoming important in context of the world as well as in Bangladesh. Because, it can improve the soil health and status for the long run and reduce the production cost of crop as well. Vermicompost is one of

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the most important organic manure having most of the macro as well as micro nutrients which is beneficial for long-term sustainability and crop productivity (Ansari *et al*., 2016). It also contains the reduced C:N ratio, increased humic acid content, cation exchange capacity and water soluble carbohydrates. Organic fertilizer release nutrients slowly for the healthy growth of plants and inorganic fertilizers avail the nutrients rapidly to meet up the immediate demand of crop nutrient. It has been reported that inorganic fertilizer in combination with organic manures also increases the carrot yield (Oliveira *et al*., 2001). Also, other vegetables like tomato, cabbage, brinjal and okra production were found higher when the one-third inorganic fertilizer was applied in combination with two-third amount vermicompost (Akhter *et al*., 2019, Islam *et al*., 2017a, 2017b, Farzana *et al*., 2019). Main target of this combination is to reduce the amount of inorganic fertilizer to improve the soil quality and reduce the production cost through reducing the amount inorganic fertilizer with supplementation of organic fertilizer.

Carrot is the most sensitive to moisture stress during root enlargement. Water stress is reported to cause small, woody and poorly flavored roots and also cause growth cracks. Carrot is the most prone to split. Splitting of roots is a disorder, usually caused by moisture levels fluctuating greatly during the growing season which deteriorates the quality of carrot. Occasionally cracking or splitting can occur at harvest time if roots have recently absorbed a sudden excess of water after a period of drought or due to lack of moisture. Proper irrigation is necessary from planting carrot seeds to harvesting for the maturation of roots. Shoot and root growth, leaf expansion, organ enlargement and stomatal functions are controlled by water (Swiader *et al*., 1994; Hamma *et al*., 2012).

Excess N fertilizer may also have an impact on splitting. Efficiently use of irrigation is the key to efficient nutrient absorption by plants to maintain the quality of carrot. Moniruzzaman *et al*. (2013) reported that maximum growth and yield of carrot was found higher with 100 kg N/ha where different amount of N was provided. To satisfy plant demand, supplementation of soil nutrient from fertilizers is necessary for better growth of carrot. Soil quality deteriorates due to overuse of chemical fertilizers. It is important to standardize the application of chemical fertilizers and organic fertilizers for proper growth and development of carrot with irrigation. So, optimum irrigation intervals and fertilization is intended to produce quality and yield commensurate with maximum returns. Hence, the present experiment is conducted to observe the effect of irrigation interval and both organic and inorganic fertilizers on growth and yield of carrot.

Materials and Methods

The research work was conducted at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh during the period from November, 2016 to March, 2017. The experimental area is located at 24° 6" North latitude and 90° 5" East longitude at an elevation of approximately 19 m from average sea level. The carrot variety used for the study was KS Koroda and it was originated in Japan. The seeds were collected from "Mousumi Beej Bitan" Notun Bajar, Mymensingh. Before sowing, the seeds were soaked in water for 24 hours and then wrapped with a piece of thin cloth to germinate quickly. Carrot seeds were sown on 13 November, 2016. Lines of about 1.5 cm depth were made and seeds were sown in line. After sowing, the seeds were covered with loose soil. After one day, plots were covered with banana leaf to protect the seed from direct sunlight. Thinning was done after seedling emergence to maintain spacing of 20 cm x 10 cm.

Irrigation was given to all the experimental plots up to the emergence of all seedlings. After that, irrigations were applied at different days interval namely no irrigation (I_0), at 7 days interval (I_7), at 15 days interval (I_{15}), at 30 days interval (I_{30}) and four different doses of organic and inorganic fertilizer were applied namely control (no fertilizer) (F_0), vermicompost (F_1) @ 15 ton per ha, mixed fertilizer (2/3 vermicompost + 1/3 inorganic fertilizer) (F_2), inorganic fertilizer (F_3) @ 150 kg urea, 105 kg TSP and 175 kg MoP per ha (FRG, 2012). The two factorial experiment was laid out in RCBD (randomized complete block design) with three replications. There were altogether 16 treatments and 48 unit plots. Irrigated plots were designed in such a way to avoid the leaching of water among the different plots. The size of a unit plot was 1m x 1 m.

All intercultural operations were done when needed. Data on growth contributing characters i.e., plant height (cm), number of leaves, length of root (cm), diameter of root (cm) and yield contributing characters i.e., fresh weight of individual root (g) were recorded from the sample plants during growing period of the crop. The gross yield and marketable yield were recorded randomly from the middle rows in each unit plot for the collection of data. It is also mentionable that data on 10 plants in a plot were averaged and considered as one replication. So, total number of plants for three replications was thirty. Harvesting of the crop was done at 100 days after seed sowing (DAS). The mean values for all the parameters were calculated and the analysis of variances for the characters was accomplished by F variance test. The significance of difference between pair of means was tested by the least significant difference (LSD) test at 5% levels of probability (Gomez and Gomez, 1984).

Results and Discussion

Main effect of irrigation interval and fertilizer on growth contributing characters

Plant height is an important growth contributing character. In general, growth rate of the plants at earlier stage was higher but it becomes slower at the later stage of development. Effect of different irrigation interval and fertilizer on plant height at different DAS (25, 40, 55, 70, 85 and 100) was found statistically significant at 5% level of probability (p= ≤5%). Plant height of carrot was maximum at 7 days irrigation interval (45.35cm) at 100 DAS and minimum (39.77 cm) at 100 DAS with no irrigation (Table 1) and similar result was found by Hamma *et al.* (2012) who reported the highest plant height at 7 days irrigation interval. Alam *et al*. (2010) also recorded the highest plant height (70.68 cm) at the highest level (four times) of irrigation. The tallest plant (47.58 cm) was obtained from mixed fertilizer (F_2) and the shortest plant (35.08 cm) was found from control (F_0) treatment of fertilizer application (Table 1). Mehedi *et al.* (2012) who found the highest plant height when N treatment was increased and mixed with the cowdung as inorganic fertilizer. Application of irrigation at 7 days interval produced the highest number of leaves (10.75) whereas without irrigation produced the lowest (8.81) (Table 1). Hamma *et al.* (2012) and Alam *et al.* (2010) also recorded the similar result where the number of leaves was 10.14 at the irrigation of 7 days interval and 12.63 at the highest level (four times) of irrigation. The highest number of leaves (10.46) was obtained from mixed fertilizer and the lowest number of leaves (8.63) was found from control treatment (Table 1). The similar result was reported by Mehedi *et al.* (2012) who got the highest number of leaves from higher amount of nitrogen and cowdung application per hectare. Maximum root diameter (3.75 cm) was recorded from the irrigation at 7 days interval and minimum root diameter (3.24 cm) was obtained from no irrigation (Table 2). The maximum root diameter (3.71 cm) was recorded from mixed fertilizer and the minimum root diameter (3.30 cm) was found from no fertilizer treatment (Table 2) which was in line with Mehedi *et al.* (2012). Irrigation treatment and fertilizer had significant effect on the root length of carrot. The maximum root length (21.11 cm) was obtained by maintaining irrigation at 7 days interval and the minimum (14.26 cm) from no irrigation (Table 2). The maximum root length (19.49 cm) was obtained from mixed fertilizer and minimum root length (15.10 cm) was found from no fertilizer treatment (Table 2).

Main effect of irrigation interval and fertilizer on yield contributing characters

The highest fresh weight of root per plant (100.05 g) was obtained from irrigation at 7 days interval and the lowest fresh weight of root per plant (78.77 g) was obtained from no irrigation (Table 2). This result was similar to Hamma *et al.* (2012) who found the highest individual root weight from more frequent irrigation i.e. at 5 days interval compared to the lower days and higher days interval of irrigation. Alam *et al.* (2010) also found the highest individual root weight (182.90 g) at the highest level of irrigation. The highest fresh weight of root (98.77 g) per plant was obtained mixed fertilizer and the lowest fresh weight of root (82.49 g) was found from no fertilizer application (Table 2) which was similar to Mehedi *et al.* (2012) and Moniruzzaman *et al. (*2013).

Irrigation at 7 days interval gave maximum gross yield per hectare (48.79 t) and the minimum gross yield per hectare (36.63 t) was recorded at no irrigation (Table 2). The result was in agreement with Hamma *et al.* (2012) who reported the highest yield from 5 days irrigation interval. Mixed fertilizer treatment produced maximum gross yield per hectare (49.50 t) and the minimum gross yield per hectare (39.00 t) was recorded from no fertilizer treatment (Table 2). The maximum marketable yield was obtained from maintaining at 7 days interval irrigation treatment (42.47 t/ha) while the minimum marketable yield (30.83 t/ha) was obtained from the treatment of no irrigation (Figure 1). The maximum marketable yield was obtained from mixed fertilizer treatment (42.67 t/ha), while the minimum marketable yield (33.27 t/ha) was obtained from the treatment of no fertilizer (Figure 2) which was in line with the findings of Mehedi *et al.* (2012). Also, other vegetables like tomato and cabbage growth and yield was found higher from the combination of inorganic and organic fertilizer (Islam *et al*., 2017a, b). Here, mixed fertilizer increased the yield of tomato including the pH of soil for the better soil quality (Islam *et al*., 2017a). Mixed of organic and inorganic fertilizer is working very well for better growth and yield of carrot including other vegetables due to available the required nutrient through application of inorganic fertilizer with supplement of organic fertilizer which release the nutrient slowly and it avail the facilities of meet up the nutrient of crop for long time during their production.

Combined effect of irrigation interval and fertilizer on growth contributing characters

The tallest plant (50.42 cm) was observed from the treatment combination I_7F_2 (mixed fertilizer with irrigation at 7 days interval) and the lowest plant height (32.75cm) was observed from no fertilizer with no irrigation) (Table 3). Result also showed that the plant height gradually increased with the increased irrigation treatment, where the tallest plant was recorded from irrigation with 7 days interval. On the other hand, the shortest plant was recorded in control with on irrigation. The increased plant height with the increasing of irrigation level might be attributed to the favorable soil moisture and temperature for proper plant growth associated with rapid increment and expansion of plant cells as stated by Sharma and Parashar (1980); Mannan and Haque (1999). The maximum number of leaves per plant (11.67) was observed from the treatment combination I_7F_2 and minimum plant height (7.83) was observed from I_0F_0 (Table 3). With the increasing time the

number of leaves increased at different DAS. At earlier stage, the number of leaves/plant was higher but it decreased gradually at later stages as also observed by Maurya and Singh (1985). The maximum root diameter (3.90 cm) was found from treatment combination I_7F_2 and the minimum root diameter (3.10cm) was recorded from the treatment combination I_0F_0 (Table 4). The level of irrigation that ensured optimum moisture availability to

Table 1. Effect of irrigation interval and fertilizer on plant height and number of leaves/plant of carrot

Treatments		Plant height (cm) at different DAS						No. of leaves/plant at different DAS					
		25	40	55	70	85	100	25	40	55	70	85	100
Irrigation Interval	I0	14.48	19.60	25.45	30.84	35.54	39.77	2.29	4.08	5.25	6.57	7.79	8.81
	I7	17.56	22.31	28.92	36.37	41.75	45.35	2.83	4.98	6.75	8.50	9.73	10.75
	I15	15.90	21.13	27.63	33.16	38.93	42.93	2.46	4.58	5.65	6.92	8.40	9.56
	I30	14.77	19.85	26.51	32.39	36.88	41.15	2.33	4.27	5.33	6.73	8.17	9.33
	$LSD_{0.05}$	0.32	0.88	0.52	0.76	0.36	1.18	0.08	0.13	0.10	0.18	0.06	0.20
	LS	*	*	*	*	*	*	*	*	*	*	*	*
Fertilizer	F0	13.42	18.46	23.55	27.80	31.38	35.08	2.21	4.15	5.27	6.63	7.63	8.63
	F1	14.35	19.27	25.21	32.46	39.44	43.01	2.29	4.31	5.44	6.83	8.29	9.38
	F2	17.96	23.13	30.69	37.49	42.70	47.58	2.83	4.81	6.27	7.92	9.29	10.46
	F3	16.98	22.04	29.05	35.01	39.58	43.52	2.58	4.65	6.00	7.34	8.88	10.00
	$LSD_{0.05}$	0.34	0.58	0.61	0.85	0.65	0.81	0.05	0.08	0.10	0.11	0.12	0.17
	LS	*	*	*	*	*	*	*	*	*	*	*	*

Table 2. Main effects of different irrigation interval and fertilizer on growth and yield contributing characters of carrot

Treatments		Diameter of roots (cm)	Length of roots (cm)	Fresh wt. of individual root (g)	Gross yield (t/ha)
Irrigation interval	I_0	3.24	14.26	78.77	36.63
	I_7	3.75	21.11	100.05	48.79
	I_{15}	3.66	17.34	97.39	47.33
	I_{30}	3.48	16.22	91.54	43.13
	$LSD_{0.05}$	0.06	0.49	1.33	1.01
	LS	*	*	*	*
Fertilizer	F_0	3.30	15.10	82.49	39.00
	F_1	3.48	16.54	90.82	42.17
	F_2	3.71	19.49	98.77	49.50
	F_3	3.63	17.81	95.67	45.21
	$LSD_{0.05}$	0.05	0.39	1.37	0.69
	LS	*	*	*	*

* = Significant at 5% level of probability. I_0= Control (no irrigation), I_7= Irrigation at 7 days interval, I_{15}= At 15 days interval, I_{30}=At 30 days interval. F_0 = Control (no fertilizer), F_1= vermicompost, F_2 = mixed fertilizer (2/3 of vermicompost + 1/3 of inorganic fertilizer), F_3= inorganic fertilizer. LS: Level of significance at $p<0.05$.

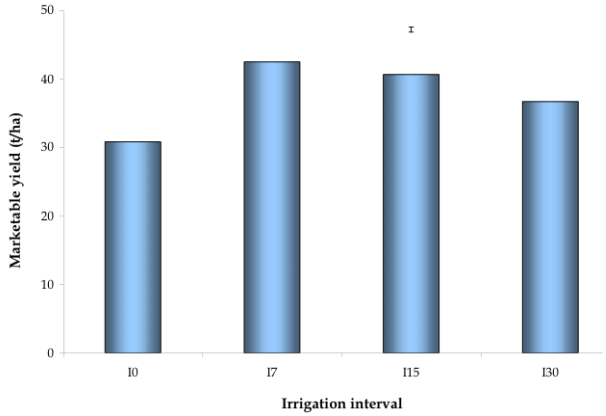

Fig.1 Main effect of irrigation interval on marketable yield. Vertical bar represents LSD at 5% level of significance. I0= Control (No irrigation), I_7= Irrigation at 7 days interval, I_{15}= At 15 days interval, I_{30}=At 30 days interval.

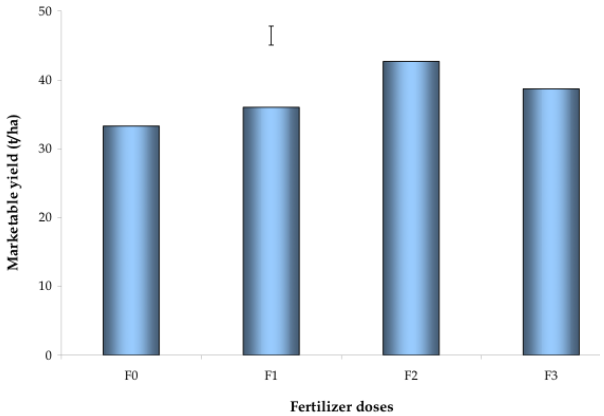

Fig. 2 Effect of fertilizer on marketable yield. Vertical bar represents LSD at 5% level of significance. F_0 = Control (no fertilizer), F_1 = vermicompost, F_2 = mixed fertilizer (2/3 of vermicompost + 1/3 of inorganic fertilizer), F_3= inorganic fertilizer

Table 3. Combined effect of different irrigation interval and fertilizer on plant height and number of leaves/plant of carrot at different days after sowing (DAS)

Treatment combination	Plant height (cm) at different DAS						No. of leaves/plant at different DAS					
	25	40	55	70	85	100	25	40	55	70	85	100
I_0F_0	11.92	17.00	22.42	25.92	29.13	32.75	2.00	3.83	4.92	6.00	6.75	7.83
I_0F_1	12.50	17.50	23.67	30.83	37.88	41.50	2.08	4.00	5.00	6.50	7.58	8.58
I_0F_2	16.92	22.08	28.83	33.83	38.58	44.42	2.58	4.25	5.58	7.17	8.42	9.42
I_0F_3	16.58	21.83	26.88	32.79	36.58	40.42	2.50	4.25	5.50	6.62	8.42	9.42
I_7F_0	15.67	20.33	24.50	29.08	33.92	38.17	2.42	4.50	6.08	7.92	9.17	10.17
I_7F_1	17.33	21.83	26.42	35.28	42.28	44.08	2.58	4.67	6.25	7.92	9.33	10.42
I_7F_2	19.08	24.00	32.92	41.13	46.29	50.42	3.50	5.50	7.67	9.58	10.67	11.67
I_7F_3	18.17	23.08	31.83	40.00	44.50	48.75	2.83	5.25	7.00	8.58	9.75	10.75
$I_{15}F_0$	13.58	18.92	23.71	28.71	31.54	35.42	2.33	4.17	5.08	6.33	7.42	8.42
$I_{15}F_1$	14.00	19.08	26.00	31.88	39.63	43.78	2.33	4.33	5.42	6.42	8.17	9.33
$I_{15}F_2$	18.00	23.42	30.96	37.88	44.63	49.42	2.67	5.08	6.08	7.75	9.08	10.42
$I_{15}F_3$	18.00	23.08	29.83	34.17	39.92	43.08	2.50	4.75	6.00	7.17	8.92	10.08
$I_{30}F_0$	12.50	17.58	23.58	27.50	30.92	34.00	2.08	4.08	5.00	6.25	7.17	8.08
$I_{30}F_1$	13.58	18.67	24.74	31.83	37.96	42.67	2.17	4.25	5.08	6.50	8.08	9.17
$I_{30}F_2$	17.83	23.00	30.03	37.13	41.29	46.08	2.58	4.42	5.75	7.17	9.00	10.33
$I_{30}F_3$	15.17	20.17	27.67	33.08	37.33	41.83	2.50	4.33	5.50	7.00	8.42	9.75
$LSD_{0.05}$	0.68	1.16	1.22	1.69	1.29	1.63	0.11	0.15	0.21	0.23	0.24	0.34
LS	*	*	*	*	*	*	*	*	*	*	*	*

Table 4. Combined effect of different irrigation interval and fertilizer on growth and yield contributing characters of carrot

Treatment combination		Diameter of roots (cm)	Length of roots (cm)	Fresh wt. of individual root (g)	Gross yield (t/ha)	Marketable yield (t/ha)
Irrigation interval x Fertilizer	I_0F_0	3.10	13.00	65.00	32.00	26.72
	I_0F_1	3.20	13.80	75.57	34.50	28.91
	I_0F_2	3.35	15.75	90.00	42.00	35.49
	I_0F_3	3.30	14.50	84.50	38.00	32.19
	I_7F_0	3.50	18.57	90.50	44.00	38.33
	I_7F_1	3.75	20.67	99.50	47.66	41.41
	I_7F_2	3.90	23.20	106.20	53.66	46.91
	I_7F_3	3.83	22.00	104.00	49.83	43.22
	$I_{15}F_0$	3.40	14.80	89.47	43.00	36.69
	$I_{15}F_1$	3.60	15.69	97.90	46.00	39.42
	$I_{15}F_2$	3.85	20.50	101.50	52.33	45.39
	$I_{15}F_3$	3.80	18.37	100.67	48.00	41.00
	$I_{30}F_0$	3.20	14.01	85.00	37.00	31.32
	$I_{30}F_1$	3.37	16.00	90.30	40.50	34.26
	$I_{30}F_2$	3.75	18.50	97.37	50.00	42.87
	$I_{30}F_3$	3.60	16.37	93.50	45.00	38.33
	$LSD_{0.05}$	0.11	0.78	2.74	1.37	0.79
	LS	*	*	*	*	*

I_0= Control (No irrigation), I_7= Irrigation at 7 days interval, I_{15}= At 15 days interval, I_{30}=At 30 days interval. F_0 = Control (no fertilizer), F_1= vermicompost, F_2 = mixed fertilizer (2/3 of vermicompost + 1/3 of inorganic fertilizer), F_3= inorganic fertilizer

plants lead to higher production of food material in the roots and ultimately resulted in the production of thicker roots of carrot. Such result was also reported by Ahmad *et al.* (2005). The longest and shortest roots (23.20 cm and 13.00 cm) were attained from I_7F_2 and I_0F_0 respectively (Table 4). The increased root length due to different irrigation interval was possibly due to availability of sufficient moisture which helped in rapid cell elongation leading to longer root formation. Ahmad *et al.* (2005) reported that root length of carrot was higher with higher amount of water level.

Combined effect of irrigation interval and fertilizer on yield contributing characters

The treatment combination I_7F_2 produced maximum fresh weight of individual root (106.20 g/plant) and the minimum (65.00 g/plant) was obtained from combination I_0F_0 (Table 4). It was observed that seven times irrigation produced the longest root having maximum diameter and that might have contributed to the maximum fresh weight of roots as stated by Ahmad *et al.* (2005). It was found that the combination of irrigation at 7 days interval with mixed fertilizer (I_7F_2) produced the highest gross yield per hectare (53.66 t) and the combination of no irrigation with no fertilizer (I_0F_0) produced the lowest gross yield per hectare (32.00 t) (Table 4). The highest marketable yield per hectare (46.91 t) was found from the combination of irrigation at 7 days interval with mixed fertilizer (I_7F_2) and the lowest marketable yield per hectare (26.72 t) was found from the combination of no irrigation with no fertilizer (I_0F_0) (Table 4). The results associated with yield contributing characters were in agreement with the findings of Alam *et al.* (2010), Hamma *et al.* (2012); Mehedi *et al.* (2012). Mulching is used to conserve the soil moisture which was in combination with mixed fertilizer gave the better result of cabbage (Farzana *et al.*, 2019). Although, black polythene showed the better performance to conserve the soil moisture which in combination with mixed of organic and inorganic fertilizer. Its indication is to maintain the properly moisture maintain and judicial application of fertilizer can give the better yield of vegetables.

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