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Effect of Spacing and Sowing Time on Growth and Yield of Carrot (*Daucus carrota* L.)

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Abstract: An investigation was carried out at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2005 to April 2006 to determine the growth and yield of carrot as influenced by different sowing dates and spacing. The study was conducted with four sowing times of carrot viz. 28 November (T_1), 8 December (T_2), 18 December (T_3) and 28 December (T_4) having three spacings viz. 20cm x 10cm (S_1), 25cm x 15cm (S_2) and 30cm x 20cm (S_3). Leaf length, root length, leaf fresh weight, root fresh weight, root diameter, leaf dry weight and root dry weight were significantly differed among the sowing times at different spacings. The maximum root length (14.82 cm), root diameter (20.39 cm), root fresh weight (217.4 g plant^{-1}) and root dry weight (32.47 g plant^{-1}) were found in T_1S_3 and the minimum of these parameters were found in T_4S_1. The percentage of cracking root and branched root of carrot was lower in T_1S_1 followed to others and it was gradually increased due to delay sowing.

Key words: Carrot · Growth · Root length · Root weight · Dry matter

INTRODUCTION

Carrot is mainly a temperate crop grown during spring through autumn in temperate countries and during winter in tropical and subtropical countries of the world [1]. According to Barnes [2], 15.6°C to 21.1°C temperature is the ideal for its growth and development. Higher and lower temperatures reduce the rate of growth and adversely affect the quality of the roots. Carrot grows successfully in Bangladesh during Rabi season when temperature ranges from 11.17°C to 28.9°C [3] and the best time is from mid November to early December for its cultivation to get satisfactory yield [4].

Vegetables are one of the most important components of human food, which provides proteins, carbohydrates, fats, vitamins and minerals. Per capita vegetable production in Bangladesh is much less than its requirement. It contains high amount of carotene (10 mg/100 g), thiamin (0.04 mg/100 g), riboflavin (0.05 mg/100 g) and also serves as a source of carbohydrate, protein, fat, minerals, vitamin-C and calories [5]. Sugar and volatile terpenoids are the two major components of carrot flavor; glucose, fructose and sucrose which make up more than 95% of the free sugars and 40% to 60% of the stored carbohydrates in the carrot root. The ratio of sucrose to reducing sugar increases with root maturity but decreases following harvest and during cold storage [6]. Blindness in children for the severe Vitamin-A deficiency is a problem of public health in some countries, particularly in the rice dependent countries of Asia [7]. So, carrot (rich in Vitamin-A) may contribute a lot of Vitamin-A to overcome this situation in Bangladesh,

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Plant spacing is one of the important factors for the increased production of carrot. Pavlek [8]; Lipari and McCollum *et al*. [10] reported that there is a positive correlation between the number of plants and yield of carrot. But many workers reported that different plant densities of spacing have different effect for the marketable yield of carrot [11, 12].

Sowing time is also an important factor for increasing yield of carrot [13]. The different sowing time of carrot have a significant effect on growth and yield due to environmental factor like temperature and light intensity [14] suggested that carrot should be harvested at proper stage of maturity. Otherwise, it will become fluffy and unfit for consumption. Moreover, the percent of root splitting, firmness, the contents of dry matter, carotene and sucrose are increased during the growth of carrot, whereas the contents of glucose and fructose and respiration quotient are decreased. The contents of total sugar remained almost constant from the beginning of the harvesting period but increased at low temperature.

To extend the availability of carrot during the early and late period of growing season and sowing time may play a critical role. Also quality of the roots depends on the harvesting time under Bangladesh condition. There is also a significant interaction between plant spacing and sowing date [15]. Therefore, the present investigation was taken find out optimum sowing time and spacing for better growth of carrot.

MATERIALS AND METHODS

The experiment was conducted at the Horticulture Farm of the Sher-e-Bangla Agricultural University, Dhaka during November 2005 to April 2006. Laboratory works were done both at Horticulture Laboratory and Soil Science Laboratory in Sher-e-Bangla Agricultural University, Dhaka-1207. The experiment area was belonged to the Modhupur Tract and AEZ 28 (FAO, 1971). The soil was sandy loam with a pH value 6.6. Soil samples were collected randomly from a depth up to 30 cm of the experimental plot and analyses were done and showed nitrogen 0.075%, phosphorus 13 ppm, exchangeable potassium 0.20 me/100g soil and organic carbon 0.82%.

New Caroda, variety of carrot, was used for the experiment. The seeds of this variety were collected from "Hamid Seed Store", Siddique Bazar, Dhaka. The experiment was conducted to study the effect of four levels of sowing times and three levels of spacing. Different levels of two factors were as follows:

Factor A: Sowing time: Carrot seeds were sown at four different times denoted as T_1,

T_2, T_3 and T_4:
T_1= 1st sowing, November 28, 2005
T_2= 2nd sowing, December 08, 2005
T_3= 3rd sowing, December 18, 2005
T_4= 4th sowing, December 28, 2005

Factor B: Spacing: Three different spacing were used denoted as S_1, S_2 and S_3

S_1= 20 cm × 10 cm
S_2= 25 cm × 15 cm
S_3 = 30 cm × 20 cm

The two factors experiment was laid out in a RCB Design with three replications. The whole experimental area was 24.5m × 8.0m, which was divided into three blocks. Each block was again divided into 12 plots and hence there were 36 (12×3) unit plots. The treatments were assigned randomly in each block separately. The size of unit plot was 2.0m ×1.5m. The distance between two adjacent blocks and plots were 1.0 m and 0.5 m respectively. Land preparation, manuring and intercultural operations were done properly.

Growth parameters were recorded at 15 days interval after 40 days of sowing and continued to harvest. Ten plants in each plot were used to count number of leaves per plant. Percentage of dry matter was calculated as follows.

$$\text{Percentage of dry matter} = \frac{\text{Fresh weight of root (g)}}{\text{Dry weight of root (g)}} \times 100$$

The recorded data on different growth and yield parameters were calculated for statistical analysis. Analyses of variances (ANOVA) for most of the characters under consideration were performed with the help of MSTAT program. Treatment means were separated by Duncane's Multiple Range Test (DMRT) at 5% level of significance for interpretation of the results.

RESULTS AND DISCUSSION

Plant Height: Four different sowing times were statistically significant in respect of plant height of carrot (Fig. 1). It varied from 53.31 cm to 26.82 cm. The maximum plant height (53.31 cm) was observed from the plants planted on 28 November (T_1) while the minimum (26.82 cm)

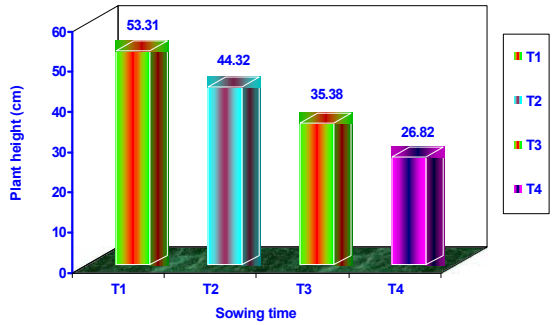

Fig. 1: Effect of sowing times on plant height (cm) of carrot

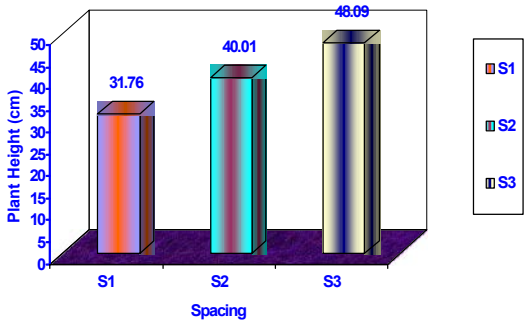

Fig. 2: Effect of spacing on plant height (cm) of carrot

on 28 December (T4). The result under the treatment T_1 predicted that early sowing performed longer plant height compared to late sowing (T_4) (Fig. 1). There were optimum environmental conditions for carrot grown on late November among the other three sowing dates. All environment factors especially temperature supported for vegetative growth simultaneously. The plant height was varied significantly due to the variation of spacing (Fig. 2). It ranged from 48.09 cm to 31.76 cm. The tallest plant was observed from the spacing of 30cm x 20cm (S_3) while the shortest from the spacing of 20cm x 10cm (S_1). The plants under the treatment of S_3 (30cm x 20 cm) had enough space for vegetative growth and had less nutritions competition compared to other plants sown under the treatment S_1 (20cm x 10 cm) and S_2 (25cm x 15cm). The findings were not agreed with Amjad and Anjum [16] due to different environmental conditions between Bangladesh and Pakistan. A significant interaction was found between sowing times and spacing on plant height (Table 1). The plant height varied from 20.12 cm to 61.65 cm. The tallest plant (61.65 cm) was observed from the treatment of T_1S_3 followed by others. The shortest plant (20.12 cm) was recorded from the treatment of T_4S_1.

Table 1: Effect of sowing time and spacing on leaves per plant of carrot

	Leaves per plant				
Spacing	T_1	T_2	T_3	T_4	Spacing mean
S_1	12.47bc	10.43cd	8.463de	6.410e	9.44b
S_2	15.27ab	13.33 bc	10.26cd	8.127de	11.75ab
S_3	18.39a	15.26ab	13.49bc	10.69cd	14.46a
Sowing dates mean	15.38a	13.01ab	10.74bc	8.408c	11.87

Means Followed by uncommon letter under the same factor are significantly differed at 5% level by DMRT.

T_1 = 28 November, T_2 = 8 November, T_3 = 18 December, T_4 = 28 December

S_1 = 20cm × 10cm, S_2 = 25cm × 15cm, S_3 = 30cm × 20cm

Number of Leaves per Plant: A significant variation was observed on leaves per plant in four sowing times (Table 1). It ranged from 8.40 to 15.38. The highest (15.38) number of leaf per plant was obtained from the plants grown at 28 November which was significantly differed from all other treatments except T_2 (8 December). The lowest number of leaves (8.40) per plant was obtained from plants grown on 28 December (T_4) which was statistically similar to the plants grown on 18 December (T_3). Results revealed that there was an increasing tendency in number of leaves per plant grown on 28 November (T_1) than 8 December (T_2) and decreasing up to 18 December (T_3) from 28 December (T_4). The present results agreed with the results obtained by Bussell and Dallenger [17]. Leaves per plant were found significant due to different spacing. The leaf number of different spacing varied from 9.44 to 14.46 (Table 1). The maximum number of leaves (14.46) was found at 30 cm × 20 cm spacing (S_3) and the minimum (9.44) was found at 20 cm × 10 cm spacing (S_1) because plants at 30 cm ×20 cm spacing could uptake more nutrients than other plants due to higher spacing. After words in treatment 30 cm × 20 cm, the number of leaves increased but decreased in other treatment due to senescence. The variation of leaves number per plant as affected by time of sowing might be to the variation in the environmental conditions during growing period. The interaction effect of sowing time and spacing showed significant variation on leaves per plant (Table 1). The number of leaves per plant varied from 6.41 to 18.39. The highest (18.39) number of leaves was recorded from the treatment T_1S_3 that was statistically similar to those of T_1S_2 and T_2S_3. The lowest (6.41) number of leaves was found from T_4S_1 that was statistically similar to those of T_3S_1 and T_4S_2.

Weight of Fresh Leaves: Weight of fresh leaves under study varied significantly due to four different sowing times (Table 2). The weight of fresh leaves varied from

Table 2: Effects of sowing time and spacing on weight of fresh leaves (g) of carrot

	Weight of fresh leaves (g)				
Spacing	T_1	T_2	T_3	T_4	Spacing mean
S_1	90.38de	72.21ef	52.96fg	40.58g	64.03c
S_2	120.4b	100.3cd	80.62de	50.98g	88.07b
S_3	150.7a	130.5b	110.7bc	70.96ef	115.7a
Sowing dates mean	120.5a	101.0b	81.43c	54.17d	89.27

Means Followed by uncommon letter under the same factor are significantly differed at 5% level by DMRT

Means Followed by uncommon letter under the same factor are significantly differed at 5% level by DMRT.

T_1 = 28 November, T_2 = 8 November, T_3 = 18 December, T_4 = 28 December

S_1 = 20cm × 10cm, S_2 = 25cm × 15cm, S_3 = 30cm × 20cm

Table 3: Effects of sowing time and spacing on weight of dry leaves of carrot

	Weight of dry leaves (g)				
Spacing	T_1	T_2	T_3	T_4	Spacing mean
S_1	39.54bc	34.16cd	27.91de	20.21f	30.46b
S_2	44.51ab	39.43bc	30.39de	23.49ef	34.46ab
S_3	48.97a	41.76ab	34.03cd	26.16ef	37.73a
Sowing dates mean	44.34a	38.45a	30.78b	23.29c	34.22

Means Followed by uncommon letter under the same factor are significantly differed at 5% level by DMRT.

T_1 = 28 November, T_2 = 8 November, T_3 = 18 December, T_4 = 28 December

S_1 = 20cm × 10cm, S_2 = 25cm × 15cm, S_3 = 30cm × 20cm

Table 4: Effects of sowing time and spacing on length of root (cm) of carrot

	Length of root (cm)				
Spacing	T_1	T_2	T_3	T_4	Spacing mean
S_1	11.13cd	10.09de	6.974fg	6.143g	8.583b
S_2	13.09b	11.66bc	8.310ef	6.923fg	9.994ab
S_3	14.82a	12.33bc	9.930de	7.010fg	11.02a
Sowing dates mean	13.01a	11.36a	8.405b	6.692b	9.86

Means Followed by uncommon letter under the same factor are significantly differed at 5% level by DMRT.

T_1 = 28 November, T_2 = 8 November, T_3 = 18 December, T_4 = 28 December

S_1 = 20cm × 10cm, S_2 = 25cm × 15cm, S_3 = 30cm × 20cm

54.17g to 120.5g. The maximum leaf fresh weight (120.5g) was obtained from the plants when grown on 28 November (T_1), which was statistically dissimilar to the plants grown on 8 December (T_2). The minimum fresh weight of leaves (54.17g) was observed when grown on 28 December (T_4). Results revealed that the weight of fresh leaf gradually decreased from T_1 to T_4. The present results were supported by Bussell and Dallenger [17].

Significant variation was found in respect of weight of fresh leaves by different spacing. The weight of fresh leaf varied from 115.7g to 64.03g (Table 2). The maximum weight (115.7g)was found to the plants were grown at the spacing of 30cm × 20cm (S_3) while the minimum (64.03g) in 20cm ×10cm (S_1). The weight of fresh leaf was gradually decreased from the plants grown from spacing S_1 (20cm×10cm) to S_3 (30cm×20cm)

The interaction effect of sowing time and spacing was statistically significant in respect of weight of fresh leaf (Table 2). The weight of fresh leaf ranged from 40.58g to 150.7g. The maximum fresh weight was recorded from the plants grown at the spacing of 30cm × 20cm and planted at 28 November (T_1S_3) while the minimum (40.58g) at the spacing of 20cm×10cm and grown on 28 December (T_4S_1) which was statistically similar to that of T_4S_2 and T_3S_1. The highest weight of fresh leaf was statistically different from the other treatment combinations

Weight of Dry Leaves: Leaves dry weight was statistically significant due to four sowing times. It varied from 23.29g to 44.34g. The highest weight (44.34 g) of dry leaves was observed in the treatment T_1 (28 November) which was statistically similar to the treatment T_2 (8 December) and the lowest (23.29 g) was found from T_4 (28 December) (Table 3). The significant result was found in respect of dry weight of leaves of carrot. It varied from 30.46g to 37.75g. The S_3 (30cm×20cm) treatment gave the maximum weight (37.75g) of dry leaves and the minimum (30.46 g) was found in treatment S_1 (20cm×10cm) that was statistically similar to the treatment S_2 (25cm×15cm) (Table 3). The combined effect of sowing time and spacing was statistically significant in respect of leaves dry weight. It varied from 20.21g to 48.97g. The maximum leaves dry weight (48.97g) was found in the treatment T_3S_1 which was statistically similar to that of T_2S_1 and T_2S_2 and the minimum (20.21g) was in the treatment T_4S_1 which is statistically significant to that of T_3S_3 and T_4S_3 (Table 3).

Root Length: The root length of carrot was significantly influenced by four sowing times (Table 4). The longest root (13.01cm) was observed from the plants grown on 28 November (T_1) which was significantly similar to the plants grown on 8 December (T_2) but significantly differed from other sowing dates. The shortest root (6.69 cm) was found from the plants grown on 28 December (T_4). This was also significantly differed from other sowing dates. A statistical similar result was also found from the treatment T_4 (28 December) and T_3 (18 December). This result showed that the root length progressively increased with the planting of late November (T_1) and early December (T_2) but decreased with the planting of mid-December (T_3) to late-December (T_4). The present

Table 5: Effects of sowing time and spacing on diameter of root (cm) of carrot

	Diameter of root (cm)				
	----------				Spacing
Spacing	T_1	T_2	T_3	T_4	mean
S_1	13.30bc	11.49de	9.327ef	8.463f	10.65b
S_2	17.40ab	14.79bc	13.48bc	11.62de	14.32a
S_3	20.39a	16.67ab	14.45bc	12.38cd	15.97a
Sowing dates mean	17.03a	14.31ab	12.42b	10.82b	13.65

Means Followed by uncommon letter under the same factor are significantly differed at 5% level by DMRT.

T_1 = 28 November, T_2 = 8 November, T_3 = 18 December, T_4 = 28 December

S_1 = 20cm × 10cm, S_2 = 25cm × 15cm, S_3 = 30cm × 20cm

Table 6: Effects of sowing time and spacing on weight of fresh root (g) of carrot

	Weight of fresh root (g)				
	----------				Spacing
Spacing	T_1	T_2	T_3	T_4	mean
S_1	136.5de	133.3de	128.1e	64.94g	115.7 c
S_2	163.7bc	158.4bc	140.2cd	88.51fg	137.7 b
S_3	217.4a	178.0b	151.4cd	94.97f	160.4 a
Sowing dates mean	172.5 a	156.5ab	139.9b	82.81c	137.88

Means Followed by uncommon letter under the same factor are significantly differed at 5% level by DMRT.

T_1 = 28 November, T_2 = 8 November, T_3 = 18 December, T_4 = 28 December

S_1 = 20cm × 10cm, S_2 = 25cm × 15cm, S_3 = 30cm × 20cm

results agreed with Rashid and Shakur [13]. There was a significant difference among the different spacings of carrot production in respect of root length (Table 4). The largest root (11.02 cm) was recorded from the plants grown at the spacing of 30cm ×20cm (S_3) which was significantly similar to the plants grown at the spacing of 25cm ×15cm (S_2) and the smallest root was recorded from the plants grown at the spacing of 20cm ×10cm (S_1), which was statistically significant compared to others. A significant interaction was found between sowing time and spacing on root length of carrot (Table 5). The root length ranged from 6.14cm to 14.82cm. The longest root (14.82cm) was recorded from the treatment T_1S_3. The shortest root (6.14cm) was found from the treatment T_4S_1 that was statistically similar to that of T_4S_2 and T_4S_3. The plants grown at the spacing of 30cm ×20cm (S_3) uptook more nutrients and rate of photosynthesis was higher than other plants so that vegetative growth was increased and the roots were rich in carbohydrate. They got more space to develop than other plants. So the root length was increased.

Diameter of Root: Root diameter exhibited significant variation among the four sowing times (Table 5). The root diameter was progressively decreased with the advance of sowing date. The highest root diameter (17.03 cm) was obtained from the plants grown on 28 November (T_1), which was statistically similar to the plants grown on 8 December (T_2). The lowest root diameter (10.82cm) was obtained from the plants grown on 28 December (T_4), which was statistically similar to the plants grown on 18 December (T_3). The findings of the present study in root diameter agreed with Bose *et al.* [1]. Significant difference was observed among the different spacing of carrot production in respect of root diameter (Table 5). The maximum root diameter (15.97 cm) was found from the plants sown at the spacing of 30cm × 20cm (S_3) which was statistically similar to that of the spacing of 25cm × 15cm (S_2) while the minimum root diameter (10.65 cm) at the spacing of 20cm ×10cm (S_1). The plants under the treatment S_3 (30cm × 20cm) had to have sufficient space to develop their root in soil so that the root diameter was increased enough than others. The findings agreed with McCollum *et al*. [10]. The interaction effect of sowing time and spacing statistically influenced the root diameter of carrot (Table 5). The root diameter varied from 8.4 cm to 20.39 cm. The highest root diameter (20.39) was observed from the treatment combination of T_1S_3 where plants were grown at the spacing of 30cm×20cm and grown on 28 November (T_1). The plants under the treatment T_1S_3 were statistically similar to that of T_2S_3.

Weight of Fresh Roots: Weight of fresh roots was significantly differed by four sowing times (Table 6). The highest fresh root weight (172.5 g) was observed from the plants grown on 28 November (T_1), which was significantly similar to the plants planted on 8 November (T_2). The lowest fresh root weight (82.81 g) was observed from the plants grown on 28 December (T_4). The results were in agreement with the findings of Rashid and Shakur [13]. They reported that carrot is a photo and thermo sensitive crop. Growth of root was developed under a sustainable environmental condition. Later sowing could not provide their suitable environmental conditions to grow up properly. So earlier sowing was the best for higher fresh weight of root. Different spacing for carrot production was found to have significant effect on fresh root weight (Table 6). It ranged from 115.7g to 160.4g. The maximum fresh root weight (160.4g) was obtained from the plants grown at the spacing of 30cm×20cm (S_3), which was significantly differed from others. The minimum fresh root weight (115.7g) was obtained from the plants

Table 7: Effects of sowing time and spacing on weight of dry root (g) of carrot

	Weight of dry root (g)				
Spacing	T_1	T_2	T_3	T_4	Spacing mean
S_1	18.61cd	15.64 de	32.47 a	8.427g	13.78b
S_2	25.44 b	18.61 cd	15.64de	11.32 fg	18.92a
S_3	32.47 a	25.44b	17.36 cd	10.57 fg	21.80a
Sowing dates mean	25.51a	20.99b	16.06c	10.10d	18.17

Means Followed by uncommon letter under the same factor are significantly differed at 5% level by DMRT.

T_1 = 28 November, T_2 = 8 November, T_3 = 18 December, T_4 = 28 December

S_1 = 20cm × 10cm, S_2 = 25cm × 15cm, S_3 = 30cm × 20cm

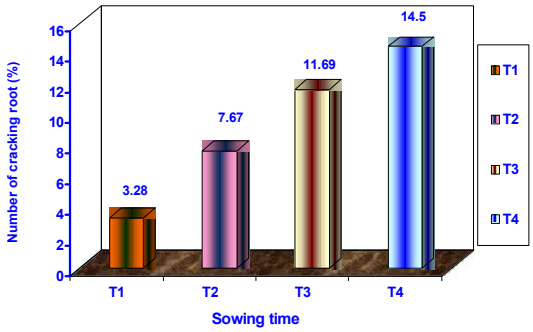

Fig. 3: Effect of sowing times on the number of cracking root percentage of carrot

grown at the spacing of 20cm×10cm (S_1). The plants, which were grown under the spacing 30cm×20cm (S_3), had more space to develop their roots and had lesser nutrient competition. Whatever the plants grown under the spacing of 25cm×15cm (S_2) and 20cm×10 (S_1) cm had comparatively less space and they had a nutrient competition among the plants. The interaction effect of sowing time and spacing was statistically significant in respect of weight of fresh root (Table 6). The weight of fresh root ranged from 217.4g to 64.94g. The maximum fresh weight (217.4g) was recorded from the plants grown at the spacing of 30cm × 20cm and planted on 28 November i.e. combined treatment T_1S_3 while the minimum (64.94g) at the spacing of 20cm×10cm and planted on 28 December i.e. combined treatment T_4S_1 which was statistically similar with T_4S_2. The highest weight of fresh root was statistically differed from other treatment combinations.

Weight of Dry Root per Plant: Significant variation of root dry weight among four sowing times was recorded which varied from 25.51g to 10.10g (Table 7). The maximum root dry weight was observed to the plants grown on 28 November (T_1) and the minimum on 28 December. It found that root dry weight was gradually decreased from 1st sowing date (T_1) to 4th sowing date (T_4). The roots were produced under optimum environmental condition like temperature, light and humidity on 28 November in compare to others. It was probably the reduction of photosynthesis and possible backflow of carbohydrate and unable to synthesize carbohydrate. Further, Reduction of root dry weight was resulted from non-accumulation of food due to aging of plants and less of stored reserved due to respiration. The effect of different spacing significantly influenced in respect of root dry weight (Table 7) which varied from 21.80g to 13.78g. The maximum root dry weight was found at the spacing of 30cm x 20cm (S_3) which was similar to the spacing of 25cm x 15 cm (S_2) and the minimum was found at the spacing of 20cm x 10cm (S_1). It resulted that wider spacing (S_3) gave more consumption of dry mater of root than less densely grown of carrot. The result was agreed by Amjad and Anjum [16]. The combined effect of four sowing times and different spacing significantly influenced the root dry weight (Table 7). The root dry weight varied from 32.47g to 8.43g. The maximum root dry weight (32.47g) was obtained on 28 November (T_1) at the spacing of 30 cm x 20 cm (S_3) i.e. The combined treatment of T_1S_3 gave the highest result and the minimum root dry weight (8.43g) was observed on 28 December (T_4) at the spacing of 20 cm x 10 cm (S_1) i.e. combined treatment of T_4S_1 gave the lowest result. The highest root dry weight represented by T_1S_3 was statistically similar with T_3S_1. The lowest root dry weight represented by T_4S_1 was statistically similar with T_4S_2 and T_4S_1.

Percentage of Cracking Root: The percentage of cracking root was varied significantly among the four sowing times (Fig. 3). The maximum cracking percentage (14.50%) was obtained from T_4 treatment i.e. delay sowing gave a huge amount of cracking roots. But the early sowing i.e. T_1 treatment gave minimum percentage of cracking root which was 3.27%. This might be caused by early sowing helps in development and vigorous growth of carrot root. The mean value of cracking percentage with the treatment of three spacing varied significantly (Fig. 4). The maximum percentage (11.73%) of cracking root was observed in the treatment of S_3 (30cm×20cm) while the minimum (6.55%) in S_1 (20cm×10cm). The combined effect of different sowing times and spacing was highly significant among the treatment mean. The maximum cracking percentage of root (18.33%) was observed from the treatment of T_3S_3 which was statistically similar with T_4S_2. The minimum (2.06%) cracking percentage of root

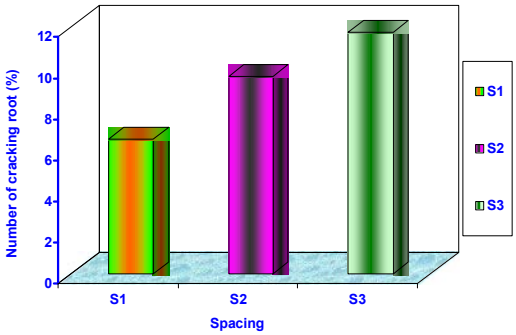

Fig. 4: Effect of spacing on the number of cracking root percentage of carrot

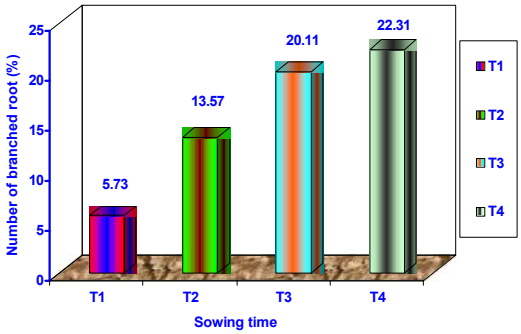

Fig. 5: Effect of sowing times on number of branched root percentage of carrot

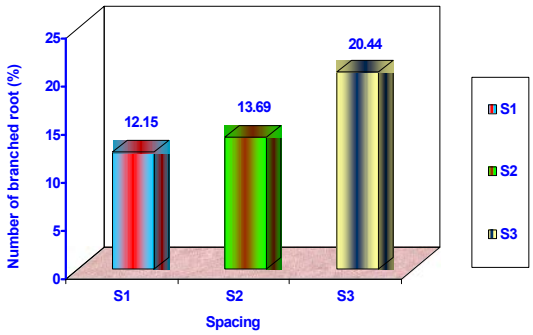

Fig. 6: Effect of spacing on the number of branched root percentage of carrot.

was observed from the treatment of T_1S_1 which was statistically similar with T_1S_2 and T_1S_3. The result showed that the early and dense sowing influenced positively on growth of plant. All the process of consumption of nutrient, air, water and light to become a competitive situation under less spacing comparatively than wider spacing.

Percentage of Branched Root: The percentage of branched root was varied significantly among the four sowing times (Fig. 5). It ranged from 5.73% to 22.31%. The maximum percentage (22.31%) of branched root was found on 28 December (T_4) which was statistically similar to that of 18 December (T_3). The minimum percentage (5.73%) of branched root was found on 28 November (T_1) i.e. delay sowing gave a huge amount of branched root. But the early sowing i.e. treatment T_1 gave minimum percentage of breached root. This might be caused by adverse environmental conditions like temperature, humidity, light and rainfall. The mean value of branched percentage with the treatment of three spacing varied significantly (Fig. 6). It ranged from 12.15% to 20.44%. The maximum percentage (22.44%) of branched root was observed to the plants planted at the spacing of 20cm x 10cm (S_1) and the minimum percentage (12.15%) of branched root was obtained at the spacing of 30cm x 20cm (S_3) which similar to the spacing of 25cm x 15cm (S_2). The result showed that the smallest spacing (S_1) gave maximum branched root percentage and minimum branched percentage was found from the highest spacing (S_3) (Fig. 5). The combined effect of different sowing times and spacing was highly significant in respect of branched root (Table 8). The maximum percentage (30.00%) was observed from the treatment of T_4S_1 and the minimum percentage (5.00%) was observed from the treatment of T_1S_3 which was statistically similar to that of T_1S_2 and T_2S_3. The result showed that the early sowing in association of dense planting effected on plant growth and development as well as the development of root.

Table 8: Interaction effect of plant height (cm), gross yield (kg/plot), gross yield (t/ha), marketable yield (kg/plot), marketable yield (t/ha),% of cracking root and% of branched root of carrot

Treatment Combination	% of cracking root	% of branched root
T_1S_1	2.067 f	5.00 g
T_1S_2	3.82 ef	6.42fg
T_1S_3	3.94 ef	5.77 fg
T_2S_1	5.00 e	9.30 ef
T_2S_2	7.54 d	11.41 e
T_2S_3	10.47 c	20.00 c
T_3S_1	6.42 de	15.00 d
T_3S_2	10.33 c	15.32 d
T_3S_3	18.33 a	30.00 a
T_4S_1	12.71 bc	19.31 c
T_4S_2	16.62 a	21.62 c
T_4S_3	14.17 b	26.00 b
CV%	15.36	13.05

Means Followed by uncommon letter under the same factor are significantly differed at 5% level by DMRT.

T_1 = 28 November, T_2 = 8 November, T_3 = 18 December, T_4 = 28 December

S_1 = 20cm × 10cm, S_2 = 25cm × 15cm, S_3 = 30cm × 20cm

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