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Impact of Planting Time on the Growth and Yield of Distinct Carrot Varieties (*Daucus carota* L.)

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ABSTRACT

This study investigated the impact of planting time on the growth and yield of distinct carrot varieties. A field experiment was conducted at Kashiadanga, Rajpara thana in Rajshahi, Bangladesh, from October 2021 to March 2022 to evaluate the effects of planting time and variety on the growth and yield of carrots. A two-factor randomized complete block design (RCBD) was employed with three replications, evaluating three planting times (P_1= 06 November, P_2= 16 November, P_3= 26 November) and three carrot varieties (V_1= KS Kuroda, V_2= Pusa Kesar, V_3= New Kuroda). Results indicated that early planting (6 November) significantly enhanced plant growth and yield attributes, including total plant length (69.96 cm), root length (16.66 cm), shoot length (53.30 cm), root diameter (33.72 mm), and total yield (25.40 t/ha). Among the varieties, Pusa Kesar demonstrated superior performance, achieving the highest plant length (74.54 cm), root length (19.00 cm), and total yield (25.39 t/ha). Combination effects further highlighted that early planting combined with Pusa Kesar maximized yield potential (28.93 t/ha). Delayed planting (26 November) resulted in reduced growth and yield, likely due to suboptimal environmental conditions. The findings emphasize the significance of optimal planting time and variety selection in enhancing carrot productivity and quality, providing valuable insights for sustainable carrot cultivation in similar agroecological zones.

Introduction

The carrot (*Daucus carota* L.), a member of the Apiaceae family, is thought to be native to the Mediterranean region (Shinohara, 1984), where it was first cultivated as a crop (Peirce, 1987). It is one of the most widely grown root vegetables in the world and is valued for both its nutritional content and culinary adaptability. Many regions of Asia, Europe, North Africa, and North and South America grow this ancient crop (Thompson & Kelly, 1957). Carrots are grown in temperate zones in the spring, summer, and fall, while they are produced in tropical and subtropical regions during the winter. Flesh-filled carrot roots are fed

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to animals and used as human food (Kadam & Salunkhe, 1998). Carrot root contains 86% moisture, 0.9 g protein, 10.6 g carbohydrate, 0.2 g fat, 1.2 g fiber, 48 kilocalories of energy, 1.1 g minerals, 2.2 mg iron, 1890 mg carotene, 0.04 mg thiamine, 0.02 mg riboflavin, 0.5 mg niacin, 3 mg vitamin C, 15 mg folic acid, 80 mg calcium, and 30 mg phosphorus per 100 g of the edible portion (Bose et al., 2003). Besides being a food, the carrot has therapeutic importance as it enhances resistance against blood and eye diseases (Kumawat et al., 2018).

In Bangladesh, carrots are an essential component of the agricultural landscape, contributing significantly to both subsistence and commercial farming. The area of carrot cultivation in Bangladesh is 5085 acres with a total production of 19246 MT (BBS, 2020). In Bangladesh, carrot is grown during the winter season when the temperature ranges from 11.70C to 28.9°C. For flowering, it often needs a comparatively low temperature. A key determinant of the quality of carrot yield is planting time. The current cropping pattern and surrounding conditions determine the ideal planting timing. It is essential to the productive production of carrots (Ahmad et al., 2011; Lutfunnahar et al., 2020). Carrot is a biennial crop and its production is greatly influenced by temperature (Bose et al., 1990). Carrots should have sufficient vegetative growth prior to cool temperature exposure as vernalization successfully induces flower formation. The amount and activity of endogenous gibberellins, which are compounds known to improve flowering characteristics in low temperatures, may be related to the difference in flowering characters across the sowing dates (Rubatzky et al., 1999). Early planting causes winter killing or late season pest infestations. Planting too late results in a lack of vernalization, this limits flowering and thus reduces seed yield. Growers tend to manipulate planting time in order to obtain better growth, more flower formation and finally higher production of quality seeds (Lutfunnahar et al., 2020).

Similarly, variety is another important factor for carrot production. In Bangladesh, there is no recommended variety of carrots. Most of the seed companies of the world produce carrot seeds to suit their own climatic conditions and if the seeds are used without an adaptability test, the growers may face economic losses (Osei et al., 2020). In this case, varietal selection plays an important role in carrot seed production. There is a vast scope for increasing the yield of carrots per hectare by using seeds of high-yielding variety. Agroclimatic changes related to the sowing date, such as variations in day and night temperatures, have an impact on the quantity and quality of carrots produced. Carrot growth and yield patterns are influenced by varietal performance and changes in climate, so the most crucial factors that cultivators should consider are the appropriate cultivar and the timing of sowing. These factors have an impact on the vegetative growth, yield, quality, and chemical composition of carrots (Ladumor et al., 2020).

Previous studies have indeed examined the growth and yield of carrot varieties in various regions and investigated the effect of different cultivation practices on carrot production. However, these studies did not specifically focus on the combined impact of planting time and varieties on growth and yield. In some cases, research has explored the influence of environmental factors on carrot growth, but it often did not differentiate between distinct carrot varieties. However, there remains a significant research gap in understanding how planting time influences the growth and yield of distinct carrot varieties in the specific agroclimatic conditions of Bangladesh. Existing literature primarily focuses on general cultivation practices and environmental factors, overlooking the potential variation in responses among different carrot varieties to planting time.

This study aims to address the research gap by systematically evaluating the performance of distinct carrot varieties under various planting time regimes. Through this investigation, we seek to elucidate the interactive effects of planting time and varietal characteristics on carrot growth and yield, thereby providing novel insights into optimizing carrot cultivation practices for enhanced productivity and sustainability in Bangladesh and elsewhere. The objectives of this research include assessing growth and yield components, identifying the most suitable variety and planting time, and ultimately providing recommendations for optimizing carrot cultivation practices based on the combination between planting time and varietal characteristics to

enhance productivity and profitability for farmers in Bangladesh.

Materials and methods

The experiment was conducted at Kashiadanga, Rajparathana in Rajshahi, Bangladesh, from October 2021 to March 2022. The soil of the experimental area was silty loam belonging to the High Ganges River Floodplain under agroecological zone-11. The site was medium-high, well-drained, with a soil pH of 7.8. In the experiment, a two-factor randomized complete block design (RCBD) was employed with three replications, and the total area was divided into 27 beds. Five shallow furrows were made for spacing of 20 cm x 15 cm with a depth of 1.5 cm in each bed. The size of the unit plot was 1.0 m × 1.0 m. The experiment consisted of three planting times: P_1= 06 November, P_2= 16 November, and P_3= 26 November. Three varieties of carrot were selected as treatments: V_1= KS Kuroda, V_2= Pusa Kesar, V_3= New Kuroda. Ploughing and cross ploughing by power tiller were done followed by laddering to obtain a good tilth condition. Urea, Triple superphosphate (150 kg/ha), and Muriate of Potash (200 kg/ha) were applied as nitrogen, phosphorus, and potassium sources, respectively. Well-decomposed cow dung at 10 t/ha was applied to the field. The total amount of cow dung and triple superphosphate and 50% of the total doses of urea and muriate of potash were applied during land preparation. The remaining amount of urea and muriate of potash was applied after 30 days of seed sowing. Seeds were soaked in water for 12 hours and then spread over tissue paper for two hours to dry. Seeds were used at a rate of 3 kg/ha and were sown on 6 November 2021. Management practices like thinning, irrigation, and insect and pest management were done as necessary to facilitate optimum crop growth. Weeding and mulching were done for four times during the experimental period to keep the plots free from weeds for conservation of moisture and better soil aeration and to break the soil crust. Roughing was done at the time of flowering to maintain varietal purity.

Data were recorded from five selected plants on total weight, root weight, shoot weight, total plant length, root length, shoot length, dry shoot weight/100 g, dry root weight/100 g, number of leaves per plant, root diameter, and yield.

The MSTAT-C package program was used to assemble and statistically analyze the collected data. The mean values of all treatments were calculated and the analysis of variance for most of the characters was accomplished by F variance test. The significance of the difference among the treatment means was evaluated using Duncan's Multiple Range Test (DMRT) at 1% and 5% levels of probability, following the method described by Gomez and Gomez (1984).

Results

Total Plant Length

Plant length was significantly affected by sowing time and variety. The maximum plant length (69.96 cm) was observed in the first planting time (6 November), while the lowest plant length (65.38 cm) was recorded in the third planting time (26 November) (Table 2). Among the three varieties, Pusa Kesar had the highest plant length (74.54 cm), followed by New Kuroda (65.06 cm) and KS Kuroda (63.71 cm) (Table 1). The combination between planting time and variety significantly influenced plant growth, with Pusa Kesar planted on 6 November achieving the highest plant length (77.27 cm), while KS Kuroda planted on 26 November showed the lowest plant length (62.20 cm) (Table 3).

Root Length

Root length was significantly affected by planting dates (Table 2). The longest root length (16.66 cm) was observed on 6 November, while the shortest (13.59 cm) was recorded on 26 November. Among the varieties, Pusa Kesar had the longest root (19.00 cm), followed by New Kuroda (14.24 cm) and KS Kuroda (12.21 cm) (Table 1). The combined effect was also significant, with Pusa Kesar planted on 6 November producing the longest root (20.80 cm) and KS Kuroda planted on 26 November yielding the shortest roots (11.37 cm) (Table 3).

Shoot Length

The tallest shoot (53.30 cm) was obtained from the first planting time (6 November), while the shortest (51.79 cm) was recorded for the third planting time (26 November) (Table 2). The combination of variety and planting time showed that Pusa Kesar planted on 16 November had the tallest shoot (56.50 cm). In contrast, New Kuroda planted on 16 November had the shortest shoot (50.53 cm) (Table 3).

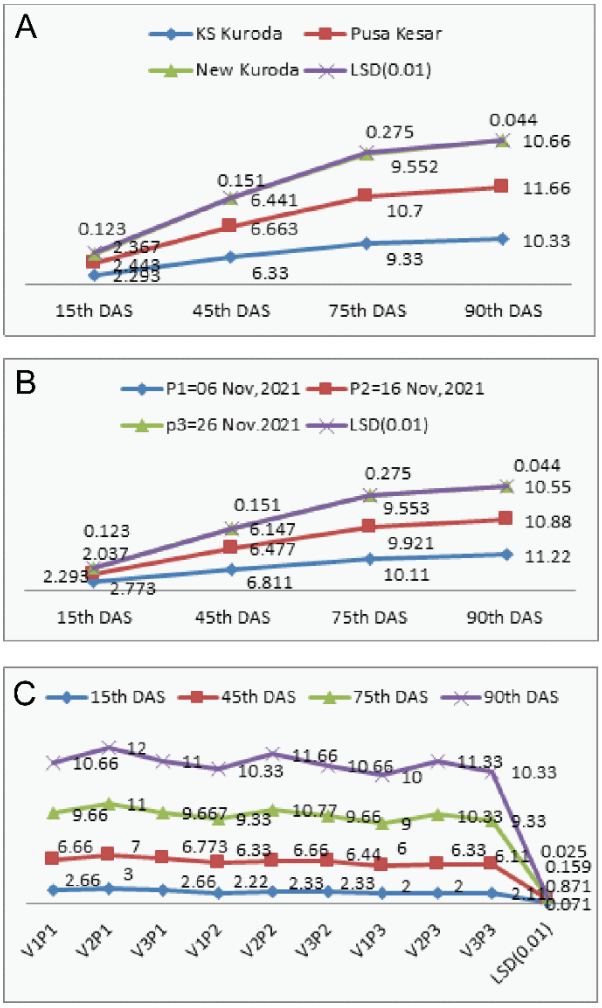

Fig. 1. Single effect of variety on leaf number of carrot (A). Main effect of planting time on leaf number of carrot (B). Combination effect of planting time and variety on leaf number of carrot V_1=KS Kuroda, V_2=Pusa Kesar, and V_3=New Kuroda, P_1=06 November, P_2=16 November, P_3=26 November (C).

Number of Leaves

Planting time significantly affected the number of leaves. The maximum number of leaves (11.22) was recorded at 90 days after sowing in the first planting (6 November), while the lowest number (2.03) was observed at 15 days after sowing in the third planting (26 November) (Fig. 2). Among varieties, Pusa Kesar produced the highest number of leaves (11.66), while KS Kuroda had the lowest (2.29) (Fig. 1). The combination between planting time and variety significantly influenced number of leaves, with Pusa Kesar planted on 6 November achieving the highest value (12), while New Kuroda planted on 26 November showed the lowest plant value (10) at 90DAS (Fig.3).

Total Weight

The highest total weight (142.40 g) was recorded for plants sown on 6 November, while the lowest (135.30 g) was found on 26 November. Among varieties, Pusa Kesar planted on 6 November had the highest total weight (149.0 g), while KS Kuroda planted on 26 November had the lowest (130.3 g) (Table 3).

Fresh Root Weight

Fresh root weight significantly varied with planting time. The highest root weight (103.6 g) was recorded on 6 November, while the lowest (102.0 g) was observed on 26 November (Table 2). Among varieties, KS Kuroda had the highest root weight (104.2 g), followed by Pusa Kesar (103.2 g) and New Kuroda (100.6 g). The combination effect showed that KS Kuroda planted on 6 November had the highest root weight (105.0 g), while New Kuroda planted on 16 November had the lowest (99.33 g) (Table 3).

Root Diameter

Root diameter significantly varied with planting time (Table 2). The highest root diameter (33.72 mm) was recorded on 6 November, while the lowest (29.37 mm) was observed on 26 November. Among varieties, New Kuroda had the highest root diameter (32.28 mm). The combined effect showed that Pusa Kesar planted on 6 November had the highest root diameter (34.72 mm), while KS Kuroda planted on 26 November had the lowest (28.04 mm) (Table 3).

Yield

Yield per hectare was significantly influenced by planting time. The highest yield (25.40 t/ha) was obtained on 6 November, while the lowest (19.80 t/ha) was recorded on 26 November (Table 2). In combination, Pusa Kesar planted on 6 November achieved the highest yield (28.93 t/ha), while KS Kuroda planted on 26 November showed the lowest yield (16.60 t/ha) (Table 3).

Table 1. Single effect of variety on growth and yield of carrot

Varieties	Total plant weight (g)	Total root weight (g)	Total shoot weight (g)	Dry shoot weight/100g of fresh shoot weight (gm)	Dry root weight/100g of fresh root weight (gm)	Diameter (mm)	Total length (cm)	Total root length (cm)	Total shoot length (cm)	Yield (t/ha)
V_1	134.00	104.20	29.78	26.67	21.43	30.15	63.71	12.21	51.50	18.90
V_2	145.40	103.20	42.11	27.26	22.53	32.05	74.54	19.00	55.54	25.39
V_3	137.00	100.60	36.44	26.71	21.89	32.38	65.06	14.24	50.81	23.28
LSD $_{(0.01)}$	1.722	2.260	1.159	1.163	0.544	1.019	0.743	0.589	1.246	1.051

Whereas; V_1= KS Kuroda, V_2= Pusa Kesar, V_3= New Kuroda

Table 2. Main effect of different planting time on growth and yield of carrot

Planting time	Total plant weight (g)	Total root weight (g)	Total shoot weight (g)	Dry shoot weight/ 100g of fresh shoot weight (gm)	Dry root weight/ 100g of fresh root weight (gm)	Diameter (mm)	Total length (cm)	Total root length (cm)	Total shoot length (cm)	Yield (t/ha)
P_1	142.40	103.60	38.89	28.60	22.99	33.72	69.96	16.66	53.30	25.40
P_2	138.70	102.40	36.22	27.34	22.02	31.48	67.98	15.21	52.77	22.37
P_3	135.30	102.00	33.22	24.70	20.85	29.37	65.38	13.59	51.79	19.80
LSD $_{(0.01)}$	1.722	2.260	1.159	1.163	0.544	1.019	0.743	0.589	1.246	1.051

Whereas; P_1=06 November, 2021, P_2=16 November, 2021, P_3=26 November, 2021

Table 3. Combined effect of variety and planting time on growth and yield of carrot

Combination of Variety *Planting time	Total plant weight (g)	Total root weight (g)	Total shoot weight (g)	Dry shoot weight/ 100g of fresh shoot weight (gm)	Dry root weight/ 100g of fresh root weight (gm)	Diameter (mm)	Total length (cm)	Total root length (cm)	Total shoot length (cm)	Yield (t/ha)
V_1P_1	137.7e	105.0a	32.67e	27.65cd	22.75b	32.04bc	65.50e	13.10f	52.40c	20.93e
V_2P_1	149.0a	104.3abc	44.67a	29.74a	23.60a	34.72a	77.27a	20.80a	56.47a	28.93a
V_3P_1	140.7d	101.3e	39.33c	28.40b	22.62bc	34.40a	67.10d	16.07d	51.03d	26.33b
V_1P_2	134.0g	104.7ab	29.33f	27.13d	21.62e	30.37d	63.43g	12.17g	51.27d	19.17f
V_2P_2	145.3b	103.3bcd	42.00b	27.02d	22.32cd	31.72c	75.53b	19.03b	56.50a	24.17c
V_3P_2	136.7f	99.33f	37.33d	27.88bc	22.13d	32.36b	64.97f	14.43e	50.53d	23.77c
V_1P_3	130.3h	103.0cd	27.33g	25.22e	19.93g	28.04f	62.20h	11.37h	50.83d	16.60g
V_2P_3	142.0c	102.0de	39.67c	25.01e	21.68e	29.70e	70.83c	17.17c	53.67b	23.07d
V_3P_3	133.7g	101.0e	32.67e	23.85f	20.94f	30.37d	63.10g	12.23g	50.87d	19.73f
LSD $_{(0.01)}$	0.994	1.305	0.669	0.672	0.314	0.589	0.428	0.340	0.719	0.607
CV%	0.90	1.60	2.33	3.14	1.80	2.35	0.80	2.83	1.72	3.39

Means followed by the same letter(s) within a column are not significantly different at the 1% or 5% level of significance, as tested by DMRT. Whereas; V_1= KS Kuroda, V_2= Pusa Kesar, V_3= New Kuroda, P_1=06 November, 2021, P_2=16 November, 2021, P_3=26 November, 2021, CV= Coefficient of Variation

Discussion

The results demonstrated that planting time and variety significantly influenced carrot growth and yield. The superior performance of early planting (6 November) can be attributed to optimal temperature and soil moisture, which favor root elongation and overall plant growth. These findings align with those of Lutfunnahar et al. (2020), Choudhary et al. (2023), and Biswas et al. (2024) who reported significant influences of planting time on plant height. Root length followed a similar trend, with earlier sowing resulting in longer roots. Pusa Kesar's genetic attributes likely contributed to its superior root length (Latha et al., 2012). This supports the findings by Dongarawar et al. (2018), and Biswas et al. (2024) who suggested that root length variation is influenced by genetic diversity and ecological conditions. Shoot length variation among different planting times and varieties indicates that environmental conditions play a crucial role in shoot growth. Sharma and Parashar (1980) and Haque and Bhuiya (1983) reported that favorable soil moisture and temperature are essential for healthy plant growth, which may explain the taller shoots observed in early planting. The number of leaves was highest in Pusa Kesar at 90 days after sowing, indicating that leaf initiation rates vary among varieties. This aligns with findings from Kushwah et al. (2019), who reported that genetic factors primarily influence leaf development. Yield and root diameter showed a decreasing trend with delayed planting, possibly due to high temperatures and higher daylight periods affecting plant metabolism. The results are consistent with Kabir et al. (2013), and Patel et al. (2015), who found that early sowing supplies more photosynthates from leaves to roots, leading to better growth. The study by MK Ali et al. (2006), and Alam et al. (2010) also confirms that delaying planting reduces growth and yield. Overall, the findings emphasize the importance of early planting (6 November) and selecting suitable varieties like Pusa Kesar for maximizing carrot yield. These results have practical implications for optimizing planting schedules for higher productivity and better root quality.

Conclusion

This research highlights the crucial influence of planting time and variety selection on optimizing carrot growth and yield. The findings indicate that early planting (November 6) significantly enhances plant length, root development, shoot growth, and overall yield by providing favorable climatic conditions for carrot development. In contrast, delayed planting (November 26) results in reduced growth and yield, likely due to unfavorable environmental conditions. Based on these characteristics, November 6 is identified as the optimal planting time. Additionally, among the tested varieties, *Pusa Kesar* outperforms others in terms of yield and growth parameters, making it the most productive variety. The study underscores that early planting, combined with high-yielding varieties, is essential for maximizing carrot productivity. These insights offer a scientific foundation for improving carrot cultivation practices, providing practical recommendations for farmers to enhance yield and profitability. Future research should focus on long-term climatic influences, soil health impacts, and breeding strategies to further improve carrot production. Implementing these recommended strategies can support sustainable agriculture, strengthen food security, and contribute to economic development in Bangladesh and other regions with similar agroecological conditions.

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Conflict of Interest

The authors declare no conflict of interests.

Authors' contribution

Conceptualization, MKA; Methodology, MKA, and FM; Investigation, FM; Data curation, AM, MAM, IN, JR, and MMH; Formal analysis, AM, IN, JR, and MMH; Visualization, FM; Writing- original draft preparation, FM; Writing-review and editing, all authors; Supervision, MKA. All authors have read and agreed to the published version of the manuscript.

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