The Effect of Different Sowing Times on Yield and Some Quality Parameters in Baby Carrots

Çiğdem Elgin Karabacak[1*], Dursun Eşiyok[2]

[1*] Pamukkale University Cal Vocational School Ismailler Mah. Camlik Parki Nr: 1 20700-Cal / Denizli, Turkey. Tel: +90 258 7512019/Fax: +90 258 7513543. E-mail: cekarabacak@pau.edu.tr

[2] Ege University, Faculty of Agriculture, Department of Horticultural Crops, Bornova-Izmir, Turkey. Tel: +90 232 311 26 21/Fax: +90 232 388 18 65. E-mail: dursun.esiyok@ege.edu.tr

ABSTRACT

This study aimed to determine the change in yield, total carotenoids and total antioxidant substances by months through identifying the optimal sowing time for the 'Parmex' baby carrot variety treated with KH_2PO_4, and grown by sowing every month for two years. The investigation of the effect of sowing time on yield showed that the highest yield was obtained in the baby carrots (25160 kg/ha) sown in February. When the yield values were examined, it was seen that the priming application increased the yield compared to the control application, but did not affect the total carotenoid and antioxidant substance amounts. In both years, the highest total carotenoid values were observed in February (14.87 mg/100g) and the lowest values were observed in March (9.52 mg/100g). In both years, the highest antioxidant substance amount was determined in baby carrots sown in March (21.84 μMolTE/100g). On average, total amounts of antioxidant substances in baby carrots ranged from 21.80 μMolTE/100g to 17.22 μMolTE/100g.

Keywords: Baby carrot, Total antioxidant substance, Total carotenoid, Yield

INTRODUCTION

Carrot has commercial value thanks to its use in nutritious processed goods such as, juices, concentrated goods, dried powder, canned goods, preservatives, confections and pickled goods. Carrot paste contains about 50% β-carotene and is profitable when used in the preparation of goods with different functions by adding into products such as cakes, breads and biscuits (Sharma et al., 2012).

The content of biologically active substances (polyphenols) in carrot root depends on various factors including the area in which the carrot is grown (agrochemical characteristic of soil), climatic conditions in the region during the growing season, cultivation technology in addition to the variety (Bystrická et al., 2015). A significant negative correlation was found between water supply and total carotenoid concentration. Total carotenoid concentration also showed a strong negative correlation with dry matter yield of marketable roots (Ombodi et al., 2014)

In baby carrot population, total and marketable yields were not affected by the different treatments. The dual bed system was more efficient since fewer seeds were used, however yields were equal to the solid-bed planting. For plant densities, the lowest density used significantly reduced yields. A seed density above 1110 seeds/m^2 did not provide any increase in population of marketable yields (Millette, 1980). Hergert (1983), in his study, did not find a significantly increased yield in bed planting over row culture for small roots of baby carrot. Yield in cultivar Esplanada was affected by the harvest time (Pr>F= <0.0001), line spacing (Pr>F= 0.0036) and year (Pr>F= <0.0001) (Lana, 2012). Liptay and Muehmer (1980) evaluated the baby carrot cultivars for various agronomic characters. The researchers have stated that the cultivar Amsterdam Minicor was typical of the third type of growth found in the carrot cultivars. The relative longitudinal and radial rates of growth resulted in the highest yields of the desired baby-size carrots. Kiraci et al. (2014) determined that the total phenolic content, antioxidant activity, β-carotene, total sugar, dry matter, soluble solid content and pH contents of carrot were significantly affected by different doses of microbial fertilizer.

The root yield of carrot was significantly affected by the application of organic manures especially groundnut cake in combination with neem cake (Kumar and Venkatasubbaiah, 2017). The maximal parameters of photosynthetic activity were obtained when sowing in the second ten-day period of March with density of 0.8 million plants per hectare, and a yield of 42.2 t/ha (Kurbanov et al., 2017). The application of poultry manure improved the physical characteristics of the soil and increased the growth and yield parameters of carrot higher than the NPK fertilizer did (Agbede et al., 2017). Maximum plant height, fresh and dry weight of shoot per plant, number of secondary, tertiary and total umbels per plant were recorded on planting date D1 (07th December) followed by D2 (17 th December) and D3 (27 th December (Umarethe, 2017). Solid matrix priming at 20°C for 24 h and osmopriming (-1.0 MPa PEG 6000 for 2 days) can be effectively used for the improvement of germination and field emergence in carrot seeds (Singh et al., 2015).

Recent social and economic developments in Turkey have led industrial agriculture organizations to search for alternative products in terms of agricultural product and production technologies. Traditional agriculture products (cotton, tobacco, etc.) fail to satisfy the needs of producers, which results in a constantly increasing demand for different products. Carrot production is a challenging process owing to its long breeding period and challenges met in its care and harvest. Therefore, thanks to their shorter production period (60-90 days) and relatively easier care conditions, baby carrots provide producers a good alternative to carrot.

Furthermore, baby carrots allow collecting multiple products from the same area and thereby, enable producers to gain a higher income. They can be bred throughout the year and thereby, can be continuously supplied to the market, which, in turn, can provide an important advantage both to producers and to businesses producing canned goods, pickled goods and frozen carrot. Unlike other carrot varieties, baby carrots are more resistant to high temperatures and drought in summer and they show hardly any blooming (Eşiyok and Elgin, 2006). In view of these advantages, producing baby carrots especially in districts close to touristic regions can help low-income producers in these regions to increase their economic gain (Yoldaş and Eşiyok, 2004; Yoldaş, 2011).

Baby carrots are not commercially produced in Turkey, albeit they are good alternative products. This study aimed to encourage baby carrot production and therefore, contribute to human health and economy by determining the distribution of total carotenoid and total antioxidant substance amounts of baby carrots by months.

MATERIAL AND METHOD

The study was carried out in the plant production area of Ege University Department of Horticultural Crops (38.454315 latitude and 27.224028 longitude, Altitude 29 m, GPS coordinates 38° 27´ 15.5340" and 27° 13´ 26.5008") by performing monthly seed sowing during a year.

'Parmex' baby carrot cultivar was used as the plant material of the study. Seeds were obtained from Thompson&Morgan seed company. In priming application, potassium dihydrogen phosphate (KH2PO4), which gives the best result for carrot seeds, was used at a 70 g/L dose (Yoldaş, 1995). Physical and chemical properties of the soil of the study area were determined in the laboratories of the E.U Soil Sciences Department of the Faculty of Agriculture by using national and international analysis methods (Table 1).

Pre-trials were carried out to determine optimum plant spacing: production was carried out in 2-m^2 pans to allow 1 g seed per m^2 at three different distances (16 cm, 12 cm, 8 cm) without dilution. According to pre-trial results, the most suitable sowing distance was 12 cm. Prior to seed sowing, parcels used for trials were processed and leveled with rotavator. Edges of the pans were placed 15-20 cm above the ground to lower water loss due to hot temperatures during summer and placed 5-8 cm above the ground to avoid the negative effects of excessive precipitation during winter.

Prior to seed sowing, 50 g sulfur and 140 g 15-15-15 composed fertilizer were fed to the soil to adjust soil pH, and were thoroughly mixed with the soil by using a rake (Vural et al., 2000). The seeds were planted every month for 2 years to the previously unplanted plots of the same land. Rotation not applied. Seed emergence occurred in 7-10 days because of the high temperatures in summer; germination and emergence times were prolonged because of the low air and soil temperatures in winter. Harvest times during each sowing period were determined by examining the plant samples collected every other 5-7 days. Harvest of baby carrots was carried out by unearthing the plants by grabbing the plants on their green sections with hands. Delayed harvests resulted in obtaining large carrots and premature harvests resulted in obtaining small carrots.

Table 1. Some physical and chemical properties of the soils in the research parcels prior to the carrot cultivation

	I. Year	II. Year
pH	7.57	7.59
Salt (%)	0.065	0.103
$CaCO_3$ (%)	3.6	2.94
Sand (%)	68.2	66.88
Alluvion (%)	19.98	27.50
Clay (%)	16.6	25.22
OM (%)	1.76	1.82
Texture	Sandy-Loamy	Sandy-Loamy
Total-N (%)	0.63	0.18
Receivable P $mgxkg^{-1}$	9.24	9.07
Receivable K $mgxkg^{-1}$	318	390
Receivable Ca $mgxkg^{-1}$	4391	4778
Receivable Mg $mgxkg^{-1}$	37.12	33.85
Receivable Fe $mgxkg^{-1}$	10.9	14.87
Receivable Cu $mgxkg^{-1}$	11.7	5.3
Receivable Zn $mgxkg^{-1}$	5.2	8.5
Receivable Mn $mgxkg^{-1}$	37.3	33.0

Table 2 shows the monthly production calendar and Table 3 shows the monthly average climate data determined during the production period (precipitation amount, relative humidity %, daily maximum and minimum temperatures).

Table 2. Production calendar for the trials

Period	Month	Seed Sowing Date	Harvest Date	Number of Days Cultivation
I. year	1	March 15th	May 25th	71
	2	April 15th	June 21st	64
	3	May 16th	July 18th	63
	4	June 16th	August 15th	63
	5	July 18th	September 13th	64
	6	August 16th	October 18th	61
	7	September 18th	December 20th	93
	8	October 17th	January 20th	92
	9	November 22nd	March 6th	105
	10	December 22nd	April 9th	109
	11	January 19th	May 7th	107
	12	February 19th	June 5th	106
II. year	1	March 13th	May 27th	75
	2	April 17th	June 22nd	66
	3	May 22nd	July 20th	66
	4	June 20th	-	-
	5	July 17th	September 24th	69
	6	August 15th	September 25th	65
	7	September 20th	January 25th	102
	8	October 17th	January 30th	105
	9	November 26th	March 11th	110
	10	December 20th	April 8th	110
	11	January 18th	May 6th	109
	12	February 15th	May 28th	103

Interciencia Journal ISSN: 0378-1844
2018 43(3)

Table 3. Monthly average climate values of the I. and II. Years

Sowing Time	Max. Temp. ºC	Min. Temp. ºC	Relative humidity %	Soil Temperature 5cm	Total precipitation mm	Max. Temp. ºC	Min. Temp. ºC	Relative humidity%	Soil Temperature 5cm	Total precipitation mm
	I. Year					II. Year				
March	18.6	6.8	61.6	13.8	5.7	19.4	7.0	58.2	13.0	_
April	22.7	10.6	55.4	18.8	9.7	25.3	11.5	43.4	18.3	10.1
May	27.3	13.9	44.1	23.9	12.0	27.8	13.4	47.1	23.4	20.7
June	32.5	18.5	37.9	30.1	_	35.7	19.0	32.3	29.8	_
July	34.7	22.8	35.8	33.7	_	36.0	20.8	38.5	33.5	_
August	36.7	21.3	39.7	34.8	_	36.8	21.9	40.9	34.9	_
September	29.9	17.3	48.0	28.0	1.7	32.0	18.0	45.0	27.0	
October	23.7	14.0	60.5	19.6	10.4	25.7	14.2	58.7	22.0	50.1
November	18.2	7.0	59.4	11.7	6.0	19.2	8.1	65.6	12.6	2.7
December	15.4	5.2	60.0	10.1	_	15.8	5.4	66.8	10.6	_
January	10.0	4.3	61.5	9.9	_	12.1	5.0	58.1	9.9	_
February	8.2	4.3	60.4	9.2	_	9.5	4.9	55.0	9.1	_

Chemicals and instruments

Unless otherwise noted, all chemicals used were obtained at an analytical grade from Sigma Chemical Company (St. Louis, MO, USA). Varian Cary 100 UV-Visible spectrophotometer was used for absorbance measurements.

Yield (kg/ha)

Roots were harvested from days 61 to 110 sowing. All roots were separated from leaves, washed, counted, weighed. The mean yield was calculated by taking the arithmetic mean of the yield values obtained in each growing season.

Dry weights of leaves and storage roots of baby carrots %:

Dry weights of leaves and storage roots of baby carrots were given in percentages. Leaves and roots of the carrots were rinsed with pure water; then, leaves and chopped root samples were placed in tared containers and their wet weights were measured with precision scales. Then, the samples were dried in an oven at 65 °C until they reached a constant weight and subsequently, their weights were measured and wet and dry weights were calculated in percentages (Kacar, 1972).

Priming:

After treatment with 70 g/L KH_2PO_4 (Merck Millipore) for 10 days, baby carrot seeds were removed from the solution, washed three times with distilled water until the active substance was removed and dried for two days at 20 °C to their original weights (Bussell and Gray, 1976; Lightburn, 1976).

Total carotenoid amount (mg/100g):

Of the samples, which were frozen after obtaining a homogeneous mixture, 5 g was weighed prior to complete-dissolution and the sample was shook 30 minutes with analytical 100 cc benzene with a shaker. Of the extracted sample, 10 ml was taken and completed to 50 ml. Of the diluted sample, 10 ml was added 10 ml ethanol and the resultant mixture were divided into two identical bottles. One of the bottles were saturated with $NaBH_4$ and the absorbance values of the samples, which were deemed ready for analysis when the solution turned yellow after adding 0.2 g NaOH tablet, were determined at 455 nm wavelength. By using the following formula, total carotenoid amounts of the samples were calculated based on their absorbance values (Baranyani and Szabolcs, 1976).

$$\text{Total carotenoids (mg/100g)} = \frac{A_{455} \times 10^3 \times 575 \times DF \times 2}{110000 \times 10} = 1.5\, A_{455} \times DF$$

A_{455} : Absorbance value determined at 455 nm

575 : Average molecular weight

110000 : Molar absorption of the carotenoids in the mixture (50% capsanthin, 10% capsorubin, 20% beta carotene, 10% lutein and %10 cryptoxanthin)

DF : Dilution Factor

Total antioxidant substance (µMolTE/100 g);

Antioxidant activity in carrot cultivars were determined in accordance with the TEAC (Trolox Equivalent Antioxidant Capacity) method proposed by Re et al. (1999). In this method, Trolox (6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid), which is an analogous of vitamin E, is used as the standard reference substance. Antioxidant activity is referred to as the Trolox equivalent and was calculated as the Trolox concentration (µmol) at which the same inhibition percentage as 1g/L concentration of the relevant compound is obtained and the results were given in µmol Trolox equivalent/100g. After a homogeneous mixture of the baby carrots is obtained, 5 g of the sample is weighed before the solution is completely dissolved. Falcon tubes containing 5 g of the sample and 25 ml ethanol are wrapped to avoid sunlight and kept 24 hours in a refrigerator. Absorbance values of the extracted samples were determined (Sanchez-Moreno et al., 1998; Pekkarinen et al., 1999; Pellegrini et al., 2003). The trial was designed in accordance with the randomized blocks experimental design and carried out in three repetitions.

Statistical analysis:

Research data were analyzed with SPSS (version 16.0) statistical package software by complying to the experimental design. The results were evaluated by considering the P (probability) values ($p<0.01$ and $p<0.05$).

RESULTS AND DISCUSSION

Results on baby carrot yields (kg/ha)

Both in the first and the second year, the effect of sowing time, seed application and sowing time-seed application interaction on the yield values of baby carrots (kg/ha) were statistically significant (p<0.01) (Table 4). In the second year, baby carrot yields failed to reach sufficient levels as a result of high air temperatures, low relative humidity and irregular irrigation. Thus, total yield values in June are not included in Table 4.

Table 4. Total yield values of baby carrots (kg/ha)

I. Year		Mar.	Apr.	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
ST*	Average (kg/ha)	17410	13450	11120	14990	7300	14090	19680	19400	22120	21010	20390	25160
SA*	Control	14810											
	Priming	18310											
STxSA*	Control	17590	12790	11970	9940	12000	6250	12130	1797	21760	18400	16600	22460
	Priming	17220	14130	12930	10310	13540	7130	27180	1855	22430	23610	24190	27870
The number of days from sowing to harvest		71	64	63	64	64	61	93	92	105	109	107	106
II. Year		Mar.	Apr.	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
ST*	Average (kg/ha)	19130	11500	13910	-	11350	10620	18300	16070	17440	16890	15340	21110
SA*	Control	13370											
	Priming	17840											
STxSA*	Control	16990	9810	11220	_	9410	9430	15270	14140	12930	15390	13800	18800
	Priming	21260	13200	16610	_	13300	11820	21320	18010	21980	18390	16890	23420
The number of days from sowing to harvest		75	66	66	_	69	65	102	105	110	110	109	103

ST: Sowing Time; SA: Seed Application

*: Statistically significant at P <0.01

The highest yield was 25160 kg/ha and obtained in the carrots sown on February and harvested on June in the first year. Compared to spring and summer seasons, the sowing of seeds in autumn and winter significantly increased the yield due to prolonged maturation period. These results are consistent with those reported by

Silva et al. (2008), which stated that delaying harvest from 80 to 110 days resulted in an increase in total root weight of mini carrots.

Results on the dry matter amounts of baby carrots (%)

In both years, the effect of sowing time on dry matter amounts of leaves and roots (%) was statistically significant (p<0.01) (Table 5).

Table 5. % dry matter amounts of baby carrots

I. Year			Mar.	Apr	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
ST*		Leaf	3,2	5,6	3,5	4,4	3,8	4,1	3,6	5,6	5,5	5,6	5,6	6,5
		Root	12,4	13,6	14,5	13,8	13,3	13,7	15,4	14,7	15,0	14,8	13,6	15,1
		Leaf+Root	15,6	19,1	18,0	18,2	17,1	17,8	19,0	20,3	20,5	20,4	19,2	21,6
SA (ns.)	Control	Leaf	3,1	4,7	3,4	4,4	3,8	4,1	3,8	5,9	5,4	5,4	5,5	6,3
		Root	12,6	13,8	14,3	13,7	13,1	13,9	15,3	14,5	14,8	15,1	12,8	15,0
		Leaf+Root	15,7	18,5	17,7	18,1	16,9	18,0	19,1	20,4	20,2	20,5	18,3	21,3
	Priming	Leaf	3,3	6,4	3,6	4,4	3,8	4,1	3,4	5,3	5,6	5,8	5,7	6,6
		Root	12,2	13,3	14,7	13,8	13,5	13,4	15,5	14,9	15,2	14,5	14,4	15,2
		Leaf+Root	15,5	19,7	18,3	18,2	17,3	17,5	18,9	20,2	20,8	20,3	20,1	21,8
The number of days from sowing to harvest			71	64	63	64	64	61	93	92	105	109	107	106
II. Year			Mar.	Apr	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
ST*		Leaf	4,2	5,2	4,8	-	4,9	4,3	4,2	5,1	5,6	5,9	5,8	6,6
		Root	12,3	13,2	14,8	-	13,7	14,5	14,1	15,0	14,1	14,8	13,5	14,8
		Leaf+Root	16,4	18,4	19,6	-	18,6	18,8	18,2	20,1	19,6	20,7	19,3	21,4
SA (ns.)	Control	Leaf	3,8	4,6	4,6	-	4,5	4,1	4,2	5,1	5,1	5,5	5,8	6,4
		Root	12,4	14,1	15,2	-	13,8	14,5	13,9	14,8	14,0	14,9	13,2	14,6
		Leaf+Root	16,2	18,7	19,8	-	18,3	18,6	18,1	19,9	19,1	20,4	19,0	21,0
	Priming	Leaf	4,5	5,8	4,9	-	5,2	4,5	4,1	5,1	6,0	6,3	5,8	6,8
		Root	12,1	12,2	14,4	-	13,6	14,4	14,2	15,2	14,1	14,7	13,7	14,9
		Leaf+Root	16,6	18,0	19,3	-	18,8	18,9	18,3	20,3	20,1	21,0	19,5	21,7
The number of days from sowing to harvest			75	66	66	-	69	65	102	105	110	110	109	103

ST: Sowing Time; SA: Seed Application; ns: Not significan

*: Statistically significant at P <0.01

Seed application had no effect on dry matter of baby carrots. In both years, the highest Leaf + Root % dry matter value was observed in the baby carrots sown in February and harvested in June (21.6% and 21.4%). The lowest dry matter amount was (Leaf + Root) 15.6% and observed in the seed sowing in March during which vegetation time was 71 days. As it is the case in the first year, in the second year, % dry matter accumulation was higher in the periods with high vegetation times than in the periods with low vegetation times. Dry matter, sugars and soluble solids accumulations in carrot storage roots were strongly correlated to increase in the mass of the roots during the plant growth. A strong relationship was found between dry matter of the storage roots and length of the vegetation period (Gajewski et al., 2009). The results of the study by Gajewski et al. (2009) are in agreement with the results obtained in our study.

Results on the total carotenoid amounts of baby carrots (mg/100g)

The effect of sowing time on total carotenoid values (mg/100g) of baby carrots was statistically significant ($p<0.01$) (Table 6). In both years, the highest total carotenoid values were observed in February (14.59 mg/100g and 14.87 mg/100g) and the lowest carotenoid values were observed in March (9.54 mg/100g and 9.52 mg/100g). There was no relationship between seed application and total carotenoid values. Sowing time-seed application interaction had no effect on total carotenoid values. The relatively lower carotenoid amounts in spring and summer were attributed to the shorter production period, whereas the relatively higher carotenoid amounts in fall and winter were attributed to the longer time spent between sowing and harvest. It was reported that carotene amount increased with prolonged growing season (Heinonen, 1990). Suslow et al. (1999) found a maximal accumulation of carotenoids in the carrot hybrid Caropak, between 90 and 97 days of cultivation. It was found that the amount of carotenoid compounds in carrots was related to longevity of vegetation period (Gajewski et al., 2009). Carotenoids accumulated in 50 to 92 days followed by stabilization, or even a small decline at day 106. The maximal accumulation of carotenoids was determined between days 85 and 92 (Simões et al., 2010). The results we obtained were compatible with those reported in the previous studies.

Table 6. Total carotenoid values of baby carrots (mg/100g)

I. Year		Mar.	Apr.	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
ST*	Average	9,54	9,59	9,59	9,56	10,59	11,43	10,74	12,77	13,08	13,82	13,48	14,59
SA (ns.)	Control	11,53											
	Priming	11,59											
STxSA (ns.)	Control	9,25	9,50	9,56	9,58	10,59	11,62	10,6	12,7	13,06	13,73	13,39	14,82
	Priming	9,83	9,67	9,61	9,55	10,59	11,25	10,89	12,84	13,10	13,9	13,57	14,36
The number of days from sowing to harvest		71	64	63	64	64	61	93	92	105	109	107	106
II. Year		**Mar.**	**Apr.**	**May**	**Jun.**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**
ST*	Average	9,52	9,89	8,94	-	10,33	11,46	10,70	12,74	12,69	14,07	12,75	14,87
SA (ns.)	Control	11,61											
	Priming	11,65											
STxSA (ns.)	Control	9,39	9,81	9,06	-	10,23	11,42	10,71	12,79	12,84	12,58	14,14	14,79
	Priming	9,66	9,97	8,82	-	10,43	11,5	10,69	12,69	12,53	12,92	14,00	14,95
The number of days from sowing to harvest		75	66	66	0	69	65	102	105	110	110	109	103

ST: Sowing Time; SA: Seed Application; ns: Not significant

*: Statistically significant at P <0.01

Results on the total antioxidant substance amounts in baby carrots (µmolte/100g)

The effect of sowing time on the total antioxidant amounts of baby carrots was statistically significant (p<0.01). As it can be seen in Table 7, in both years, the highest antioxidant amounts were observed in March (21.76 µmol TE/100g and 21,84 µmol TE/100g) in which production period for baby carrots was 71-75 days, whereas the lowest antioxidant substance amount (17.4 µmol TE/100g) was observed in the long period in which vegetation was 107-109 days-long. In the first year, the lowest antioxidant substance amount was 17.14 µmol TE/100g and observed in January; in the second year, the lowest antioxidant substance amount was 17.21 µmol TE/100g and observed in August.

Table 7. Total antioxidant substance amounts in baby carrots (µmol TE/100g)

I. Year		Mar.	Apr.	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
ST*	Average	21,76	20,47	21,12	18,47	17,35	17,22	20,3	19,52	19,62	18,19	17,14	19,89
SA (ns.)	Control	19,52											
	Priming	19,34											
STxSA (ns.)	Control	21,67	20,9	20,86	17,89	17,96	18,1	20,45	19,73	19,47	18,29	16,78	19,25
	Priming	21,85	20,03	21,37	19,06	16,75	17,69	20,16	19,31	19,77	18,09	17,51	20,57
The number of days from sowing to harvest		71	64	63	64	64	61	93	92	105	109	107	106
II. Year		**Mar.**	**Apr.**	**May**	**Jun.**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**
ST*	Average	21,84	18,35	19,95	-	18,63	17,21	17,97	19,34	17,48	17,7	18,65	19,5
SA (ns.)	Control	18,82											
	Priming	18,74											
STxSA (ns.)	Control	21,28	18,09	20,11	-	18,17	17,22	18,66	19,84	17,69	18,61	18,63	18,8
	Priming	22,4	18,61	19,79	-	19,08	17,2	17,29	18,85	17,28	16,79	18,67	20,2
The number of days from sowing to harvest		75	66	66	-	69	65	102	105	110	110	109	103

ST: Sowing Time; SA: Seed Application; ns: Not significant

*: Statistically significant at P <0.01

According to the TEAC method, antioxidant activity levels of the carrots varied between 21.84 µmol TE/100g and 17.14 µmol TE/100g. The highest total antioxidant substance amounts (21.76 µmol TE/100g and 21.84 µmol TE/100g) were observed in March. The amount of total antioxidant of the baby-carrots sown in spring was higher compared to the results of other seasons. Although the literature related to the antioxidant activity of carrots on post-harvest studies is rich, the number of studies on production period of carrots is limited and their results cannot be compared to the present study.

CONCLUSION

Cultivation season, climatic factors and priming application were the factors predominantly affecting baby carrot yield. Priming application allows seeds to grow in a short time and at high speed. Rapid rooting and shoot-out lead to stronger seedling growth and consequently increased yield. It is known that the most important climate factor affecting carrot cultivation is temperature. The climatic factors during the growing period of the plants cultivated in February and harvested in June met the optimum temperature requirements of the carrot and this affected carrot yield positively.

The maturity, climate or season, and cultivation affect the composition of carotenoids. The length of growing season was the major factor effecting dry matter, total carotenoids and yield properties of baby carrots. In months with increased dry matter amounts, carotenoid values also increased. Total antioxidant substance values of baby carrots reached relatively higher values in spring. Furthermore, it can be said that baby carrots can be grown throughout the year. Thus, these results provide an indication for farmers. However, further investigations are required to compile a more comprehensive database.

.

ACKNOWLEDGEMENTS

We would like to thank the Ege University Scientific Research Project Commission for supporting this research with the Project No. BAP- ZRF-004.

Authors' contributions

Regulation of article, laboratory and field application studies were carried out by Çiğdem ELGİN KARABACAK. Determination of breeding method, follow-up of the application of the study in the determined criteria and statistical analysis studies were carried out by Dursun EŞİYOK.

REFERENCES

Agbede, T.M., Adekiya, A.O., Eifediyi, E.K. (2017). Impact of poultry manure and NPK fertilizer on soil physical properties and growth and yield of carrot.

Baranyani, M., Szabolcs, J. (1976). Determination by reduction of the red and total pigments content in paprica products. Acta Aliment, 5(2), 87.

Bussell, W.T. and Gray, D. (1976). Effects of pre-sowing seed treatments and temperatures on tomato seed germination and seedling emergence. Scientia Horticulturae, 5, 101-109.

Bystrická, J., Kavalcová, P., Musilová, J., Vollmannová, A., Tóth, T., Lenková, M. (2015). Carrot (Daucus carota L. ssp. sativus (Hoffm.) Arcang.) as source of antioxidants. Acta agriculturae Slovenica, 105 - 2.

Eşiyok, D., Elgin, Ç. (2006). Mini (Baby) carrot breeding. World Food Journal, 10, 90-91.

Gajewski, M., Szymczak, P., Bajer, M., 2009. The accumulation of chemical compounds in storage roots by carrots of different cultivars during vegetation period. Acta Sci. Pol., Hortorum Cultus, 8(4), 69-78.

Heinonen, M. I. (1990). Carotenoids and provitamin A activity of carrot (Daucus carota L.) cultivars. J. Agric. Food Chem. https://doi.org/10.1021/jf00093a005.

Hergert, G. B. (1983). Production techniques for baby carrots and small red beets. Can. Agric. Eng, 25, 33-37.

Kacar, B. (1972). Chemical analysis of plant and soil. II. Plant Analysis, Ankara University Agricultural Faculty Publications, Ankara.

Kiraci, S., Gönülal, E., Padem, H. (2014). The effects of different mycorrhizae species on quality properties in organic carrot growing. Journal of Tekirdag Agricultural Faculty, 11 (1), 106-113.

Koca, N. (2006). Carotenoids and antioxidant activity in carrots (Daucus carota L.). (Doctoral dissertation), Ankara University, Ankara.

Kumar, G.S and Venkatasubbaiah, Y. P. (2017). Root yield and nutrient uptake of carrot (Daucus carota L.) as influenced by the application of different organic manures. Int. J. Pure App. Biosci. 5 (5): 131-138.

Kurbanov S.A., Magomedova D.S., Kurbanova L.G (2017). Growing and development particularities in carrot sown in different terms in plain area of Dagestan. Vegetable Production Journal. 1(34), 55-58.

Lana, M.M. (2012). The effects of line spacing and harvest time on processing yield and root size of carrot for Cenourete® production. Horticultura Brasileira, 30, 304-311.

Lightburn, D.J. (1976). Osmotic pre-treatment of tomato seeds and their subsequent growth. Dept. Of Agric. And Hort. Univ. Of Nottinghom, School of Agric. Sutton Bonington, Loughborough.

Liptay, A., Muehmer, J. K. (1980). Evaluation of baby carrots and their growth patterns in southwestern Ontario. Can. J. Plant Sci. 60, 911-915.

Millette, J.A., Bernier, R., Hergert, G.B. (1980). Baby carrot production system on organic soils. Can. Agric. Eng, 22, 175-178.

Pekkarinen, S. S., Stockman, H., Swarz, K., Heinonen, M. I., Hopia, A. I. (1999). Antioxidant activity and partitioning of phenolic acids in bulk and emulsified methyl linoleate. J. Agric. Food Chem, 47(8), 3036-43.

Pellegrini, N., Serafini, M., Colombi, B., Del Rio, D., Salvatore, S., Bianchi, M., Brighenti, F. (2003). Total antioxidant capacity of plant foods, beverages and oils consumed in Italy assessed by three different in vitro assays. J. Nutr, 133, 2812-2819. inoleate. J. Agric. Food Chem, 47, 3036-3043.

Re, R., Pellegrini, N., Proteggente, A., Pannala, A., Yang, M., Rice-Evans, C. A. (1999). Antioxidant activity applying an improved ABTS radical cationdecolorization assay. Free Radical Biology and Medicine, 26, 1231–1237.

Sanchez-Moreno, C., Larrauri, J. A., Saura-Calixto, F. (1998). Journal Sci. Food Agric., 76, 270.

Sharma, K.D, Karki, S., Thakur, N.S., Attri, S. (2012). Chemical composition, functional properties and processing of carrot—a review, J Food Sci Technol, 49(1), 22–32.

Silva, J.B.C., Vieira, J.V., Lana, M.M. (2008). Processing yield of the carrot cultivar Esplanada as affected by harvest time and planting density. Scientia Horticulturae, 115, 218–222.

Simões, AN., Moreira, SI., Costa, FB., Almeida, AR., Santos, RHS., Puschmann, R. (2010). Populational density and harvest age of carrots for baby carrot manufacture. Horticultura Brasileira, 28, 147-154.

Singh P.K., Pandita,V.K., Tomar, B.S. and Seth, R. (2015). Standardization of priming treatments for enhancement of seed germination and field emergence in carrot. Indian J. Hort. 72(2), 306-309

Suslow, TV., Wu, J., Peiser, G. (1999). Characterization of carotenoid composition of carrots affected by “Light Root Syndorme”. Perishables Handling Quarterly Issue, 100, 11-14.

Ombodi, A., Daood, HG., Helyes, L. (2014) Carotenoid and Tocopherol Composition of an Orange-colored Carrot as Affected by Water Supply. Hortscience, 49(6), 729–733.

Umarethe, K. (2017). Effect of Date of Planting and Gibberellic Acid on Yield and Quality of seed in Carrot (Daucus carota L.). Gwalior College of Horticulture Graduate Thesis. 124 pages.

Vural, H., Eşiyok, D., Duman, I. (2000). Culture vegetables (vegetable growing). Ege Univ. Printing house, Izmir.

Yoldaş, F. (1995). Investigation of the effects of different applications on the germination and emergence of the seeds of carrot (Daucus carota L.) before sowing.. Ege University Department of Horticulture Graduate Thesis. 80 pages.

Yoldaş, F., Eşiyok, D. (2004). Effects of temperature plant spacing sowing/planting date on generative growth and yield components of broccoli. 39th Croatian Symposium on Agriculture with International Participation (pp 17-20). Opatija, Croatia.

Yoldaş, F. (2011). Searching for alternative vegetable products in Little Menderes basin. Yüzüncü Yıl University Journal of The Institute of Natural & Applied Sciences, 16(2), 54-58.