

Growing endive plants (*Cichorium endivia* L. Var. *Crispum*) under different planting dates and spacing in Egypt

Abstract

This investigation was carried out on the curled endive (*Cichorium endivia* L. var. *Crispum*) cv. Salad King in private farm located at El-Giza governorate, Egypt during the two successive seasons of 2012/2013 and 2013/2014 A.D. Seedlings of endive were transplanted on October 15th, November 15th and December 15th and three planting space were used (10, 15 and 20cm) in both growing seasons. The highest values of plant length and leaves number per plant were obtained from transplanting in October 15th with the spacing 20cm in both seasons respectively. The greatest value of ascorbic acid and dry weight were obtained from transplanting in October 15th. In addition the best plant spacing for ascorbic acid content was 15cm and for dry weight 20cm. Total sugar, inulin, fresh weight per rosette (g) and yield per plot (kg) were obtained from transplanted on October 15th. However, the highest amount of total sugar and inulin were found from grown plants in spacing 15cm, while the fresh weight per rosette was obtained from spacing 10cm and yield per plot was obtained from spacing 15cm among plants.

Keywords: endive, ascorbic acid, total sugars, inulin, yield, *cichorium endivia* L.

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Introduction

Endive (*Cichorium endivia* L. var. *crispum*, a member of *Asteraceae* family) is a long day plant and the optimal temperature for endive growth is 15-18°C. The growth period of the plant is about 70-100 days and high sunlight stimulates the flowering.¹ Endive, (*Cichorium endivia* L.), an annual plant, belonging to leafy vegetables group, has become very popular in West European countries. Endive characterizes a considerable nutritive value, as well as distinctive, slightly bitter taste. The plant occurs in two botanical varieties, endive (*Cichorium endivia* L. var. *crispum* Hegi) of a curly, mares tail shape of leaves and escarole (*Cichorium endivia* L. var. *latifolium* Hegi) featuring smooth leaves.^{2,3} However, in other European countries – mainly in Italy, Spain, France and Greece, endive is a very popular leafy vegetable and it is grown in the open field as well as under covers.⁴ The two principal types of endive are curled with fringed and curly leaves and escarole, which has broader, thicker, smooth leaves.⁵ Endive is one of the most nutritious and health benefits leafy vegetables. It contains more of minerals (especially phosphorus, calcium and potassium), pro-vitamin A and vitamins B1, B2 and C, in comparison with lettuce which is more popular in our country. Because of the high content of bitter compounds endive has properties aiding in digestion.⁶ Endive is a long – day plant, of a short growing period and high, similar to that of lettuce.⁷

It was found that lettuce plant height increased from increasing distance between plants⁸ and from transplanting in early appointment compared with plants were grown late.^{9,10} On sweet pepper, it was found that the tallest plant was obtained from the cultivation in October 1st.¹¹ In endive, it was found that the maximum leaf length was recorded when plants were sown in June 30th, compared with plants which sown in 10 and June 20th and July 10th.¹² On other hand sweet

pepper planted in August 20th with space distance 60cm produced the higher mean values of plant height, compared with the other late planting dates with closest space.¹³ On molokhia, the longest plant was recorded when plants were sown in April 25th compared with sowing in February 25th.¹⁴ The same studies on chicory, it was found that the tallest plant was recorded at March 15th plantation compared with plants which sown in February 15th and April 15th. In a study on chicory, it was found that the maximum plant height was obtained from widest spacing (10 plants m²) compared with plants which sown in close distances (12.5, 16.7 and 25 plants m²).¹⁵ On lettuce, it was found that the widest space of (40x40cm) produced the highest value of leaves number per plant (in both seasons) compared with 40x20 and 40x30cm.⁸ On the same plants maximum value of leaves number was recorded when plants cultivated in November 5th compared with November 20th and December 5.¹⁶ The maximum value of leaves number per plant obtained from cultivated sweet pepper in August 20th and spacing at 60cm compared with other planting dates and spacing.¹³ Recently on lettuce, it was found that the highest value for the average number of leaves/head was recorded with the third transplanting date (Jan 15th in the first season. While in the second season the highest values were recorded by the second transplanting date (Nov 15th).¹⁷

It was found on chicory cv radicchio, that the maximum ascorbic acid value recorded when plants were sown on spring, compared with plants were sown in summer.¹⁸ In kohlrabi cultivation exhibited the maximum ascorbic acid content was recorded at spacing 20x15cm compared with plants were sown about spacing 25x20cm.¹⁹ However on broccoli, it was found that the maximum ascorbic acid value recorded at spacing 60x30cm compared with 60x45cm and 60x60cm.²⁰ The wider spacing in lettuce (40x40cm) produced the maximum dry weight of the plant compared with plants were sown

about spacing 40x20 and 40x30cm.⁸ The same studies on Chinese cabbage, it was found that the maximum value of dry weight recorded when plants were sown about spacing 50x40cm compared with plants were sown about spacing 50x20 and 50x30cm. The maximum value of dry weight kohlrabi plants were recorded at 25x20cm compared with plants were sown about spacing 20x15cm.¹⁹ The wider spacing 40x30cm produced the maximum dry weight in lettuce plant compared with others spacing 40x20 and 40x25cm.²¹ On the other study on lettuce, it was found that the maximum value of dry matter recorded when plants were cultivated in November than others were earlier.⁹ In contrast, Singer et al.,¹⁷ reported that transplanting lettuce in September 15th gave the elevated dry matter percentage compared with others dates were later. In another study on chicory cv radicchio, it was found that the highest total sugar value recorded when plants were sown on spring, compared with plants were sown in summer.¹⁸ The highest inulin was obtained from planting chicory in March compared with planting in April.²² Inulin was reach the maximum level when cultivated Jerusalem artichoke in September and March with wider spacing 50 and 40cm.^{23,24} A more objective approach to determine the growth of vegetable crops is testing of plant fresh weight. In experiment on lettuce, it was found that the widest spacing (40x40cm) produced the greatest fresh weight per plant compared with 40x20 and 40x30cm.⁸ On endive, it was found that the maximum fresh weight recorded at the widest spacing 40x35cm compared with 40x25cm. The maximum fresh weight of lettuce was recorded when plants were sowing in November 5th compared with plants were sowing in November 20th and December 5th in all varieties.¹⁶ On spinach it was found that the highest total weight was obtained from April 30th cultivation, while it was the best planting dates for lettuce leaves weight achievement in November 15th.^{17,25} Concerning to the spacing, it was found that the highest yield was obtained from lettuce at closer spacing (40x20 m) with the best planting date was from September 23th to October 14th.^{8,9} On endive, it was found that the maximum yield was recorded when plants were grown at spacing 40x25cm.²⁶ The best planting date to harvest highest yield was in May 19th on Spinach,²⁵ and in November 15th on lettuce.¹⁷ Endive is also a crop of little climatic requirements. However, long lasting drought and high air temperatures can cause bolting (premature flowering). From the point of view of quantity and quality of the yield it seems to be important to specify the best planting date for growing endive in open field conditions. Moreover, one of the most important factor determining productivity of the crop cultivation is plant density. The objectives of these study aimed to study the effect of planting dates and spacing on growth and yield in endive plants to determine the best date and space for planting in order to get the best growth and yield quantity and quality.

Materials and method

This investigation was carried out during the two successive seasons of 2012/2013 and 2013/2014 on endive (*Cichorium endivia* L. var. *crispum*) Cv. Salad king. The experiment of design was completed randomized blocks. Treatments (three transplanting dates and three planting spaces) were replicated four times. Seedlings of endive were transplanted on (October 15th, November 15th and December 15th) in the two growing seasons. Seeds of endive were sown in seed trays one month ago from each transplanting date respectively. There were 3 transplanting distances which comprised (10, 15, and 20cm). The treatment included four replicates and each replicate consisted of 5 rows, every row was 3.5m long and 70cm width. The plot area was 12.25m². Ten plants from every replicates after harvesting were chosen

for the physical and chemical analyses. The aim of this experiment is to know the best transplanting date and space for endive plants to get the highest yield and the best quality.

Data were recorded from each plot as follow:

- i. Vegetative growth characteristics: Data were taken after three months from transplanting on: Plant length (cm), leaves length were measured by ruler and leaf number were counted manually.
- ii. Chemical characteristics: Chemical parameters such as ascorbic acid (mg/100g f.w.) were determined according to A.O.A.C.,²⁷ total sugars content was measured as (% d.w.) according to Smith et al., (1956), inulin (% d.w.) were measured according to A.O.A.C.²⁷ and dry weight (g/100g).
- iii. Yield characteristics: Fresh weight per rosette (g) and total yield per plot (kg) were weighted during the whole period of harvesting.

Statistical analysis

All experiments were statistically analyzed in a complete randomized design with four replicates. Obtained data were subjected to the analysis of variance procedure and means were compared by L.S.D. method at 5% level of significant according to Snedecor et al.²⁸

Results

The exhibited results showed the effect of transplanting dates and spacing on endive plants during seasons of 2012/2013 and 2013/2014 were tabulated in the Table 1. It is clear that the highest values of plant length and leaves number per plant was obtained with transplanting in October 15th with register number 35.10 and 36.65cm while leaves number were 60.78 and 65.57 in both seasons respectively. The obtained results showed a significance differences among all treatments. The lowest values were recorded with transplanting in December 15th with recorded number 28.95 and 29.60cm while leaves number were 50.36 and 52.28 during both seasons respectively. It is also, clear from the data that, there are significant differences among planting space treatments. The highest values of plant length and leaves number per plant were obtained with distance of 20cm gave values 34.97 and 35.72cm, meanwhile were 60.38 and 61.86 for leaves number in both two seasons respectively). Meanwhile the least values were 30.21 and 31.63cm and leaves number were 50.32 and 55.37 with space of 10cm between plants during both experimental seasons. Regarding to the interaction between transplanting dates and spacing, it was noticed that the highest significant value of plant length and leaves number per plant were obtained due to transplanting in October 15th with distance of 20cm between plants with registered values for plant length were 37.68 and 39.03cm, while were 66.81 and 69.29 for leaves number in two seasons respectively. On the contrast the lowest values for plant length were (27.07 and 27.67cm) and leaves number per plant (46.21 49.18) were obtained with transplanting in December 15th with distance of 10cm between plants in both two growing seasons of study.

Ascorbic acid is important antioxidants extracted from endive leaves and was significantly affected by planting dates during both two seasons 2012/2013 and 2013/2014 (Table 2). Data shown that the greatest value of ascorbic acid (21.00 and 22.57mg/100g) was obtained with transplanting in October 15th, while the least values (17.55 and 17.77mg/100g in both two seasons respectively) were recorded with transplanting in December 15th in both two growing seasons of study

respectively. Referring to the effect of planting space on ascorbic acid contents data showed that there were significant variations in all treatments. From data, the maximum value of ascorbic acid content (20.82 and 21.75mg/100g) in both two seasons respectively were recorded with distance of 15cm between plants, while the minimum values (18.35 and 19.34mg/100g) were obtained from with distance of 10cm between plants in two seasons respectively. Concerning to the interaction between transplanting dates and spacing data presented in Table 2. The results revealed that, substantial effects were produced by the combination of transplanting dates and spacing, Data shown that there no significant difference between combination of planting dates and spacing. The maximum values of ascorbic acid of endive leaves (22.06 and 23.85mg/100g) were obtained with transplanting in October 15th with distance of 15cm between plants, meanwhile the minimum values (16.27 and 16.65mg/100g) were obtained with transplanting in December 15th with space of 10cm between plants in the first and the second seasons respectively.

Data presented in Table 2, clearly demonstrate the effect of the transplanting dates on dry weight of endive leaves during 2012/2013 and 2013/2014 seasons. Results showed that there were significant differences in all transplanting dates. The greatest dry weight content (6.53 and 6.64g/100g) were recorded with transplanting in October 15th, while the lowest values of dry weight content (5.29 and 5.39g/100g) was recorded with transplanting in 15th December in both seasons respectively. Data, also, indicated that there were significant variations between spacing treatments, the highest dry weight (6.51 and 6.61g/100g) were obtained from plants which planted with distance of 20cm between them, the lowest values (5.43 and 5.54g/100g) were obtained from plants with space of 10cm between them in both seasons. The interaction effects between transplanting dates and spacing were non-significant. The combination between transplanting dates and spacing showed that the highest values of dry weight (7.06 and 7.17g/100g) were recorded from planted on 15th October at 15cm between plants, while the lowest value (4.84 and 4.95g/100g) was recorded from transplanting in December 15th with distance of 10cm among plants in first and second seasons respectively.

The effect of transplanting dates on total sugars of endive plants was showed in Table 3. Data cleared that this character significantly increased with transplanting dates treatments in both seasons. So that, the transplanting date treatment (October 15th) produced the largest total sugars (2.25 and 2.33 % in both seasons respectively), meanwhile the planting date treatment (December 15th) gave the lowest one (1.38 and 1.44g/100g) in two seasons. On the other hand, regarding to spacing treatments, there was a significant difference in total sugars with the spacing treatments. The highest total sugars content (2.09 and 2.10 %) were obtained with distance of 15cm between plants, while the lowest value (1.68 and 1.85 %) were obtained with distance of 10cm between plants in two growing seasons respectively. The interaction between planting dates and spacing has non-significant effect on total sugar. The highest values (2.41 and 2.49g/100g) were obtained from the plants that planted on 15th October and spacing at 15cm among plants in both seasons respectively. While the lowest values were obtained from plants that planting on 15th December at 10cm among plants (1.18 and 1.29g/100g) in both seasons respectively. Regarding to the parameter of inulin, data in Table 3 showed that all transplanting dates treatments differed significantly in inulin of endive. On the other side, the maximum value of inulin was obtained with transplanting in

October 15th (0.53 and 0.55 % in both seasons respectively). While the plants which transplanting in December 15th gave the minimum inulin value (0.40 and 0.43%). It is also, clear from the data that, there were significant differences between planting space treatments. The highest values of inulin recorded (0.53 and 0.55%) were obtained with grown plants at spacing 15cm in the first and the second seasons respectively, meanwhile the least value records (0.41 and 0.45%) in both seasons respectively were obtained from planting about 10cm between plants. The interaction between planting dates and spacing was differed significantly. The highest inulin records (0.60 and 0.62%) were produced by planting on 15th October at 15cm among plants in the two seasons respectively, while the lowest values were obtained from planting on 15th December about 20cm among plants (0.35 and 0.38%) in seasons 2012/2013 and 2013/2014 respectively.

Data presented in Table 4 which demonstrated that the effect of transplanting dates and spacing on fresh weight per endive rosette leaves during 2012/2013 and 2013/2014 seasons. Data cleared that there were significant differences between transplanting dates treatments, however the greatest values (402.89 and 408.05g/rosette) were recorded with transplanting in October 15th, while the lowest values (385.41 and 388.74g) were obtained from the plants which transplanted in December 15th in both two growing seasons respectively. It is also, clear from the data that, there were significant differences between which transplanting spacing treatments. The highest values of fresh weight per rosette were recorded (472.59 and 477.62g/rosette) which obtained from transplanting with distance of 20cm between plants in the first and the second seasons respectively, while the lowest values of fresh weight per rosette (276.83 and 281.33g) were obtained from transplanting endive with distance of 10cm between plants during both seasons respectively. The interaction between transplanting dates and spacing exhibited significant differences among all treatments. The highest values of fresh weight per rosette recorded (481.57 and 484.95g/rosette) were produced by transplanting in October 15th with distance of 10cm between plants in both two seasons respectively, while the lowest values were obtained from transplanting in December 15th with distance of 10cm between plants (266.95 and 269.68g/rosette) in both seasons respectively. Regarding to the data presented in Table 4, the results revealed that planting dates has a significant effect on yield of endive plants during 2012/2013 and 2013/2014 seasons. The highest yield was obtained by grown endive plants at 15th October with values 22.75 and 23.98kg/plot in both two seasons respectively, meanwhile the lest value (18.95 and 19.06 kg/plot) recorded when plants were planted in 15th December in both two growing seasons respectively. Concerning to the effect of plant spacing on endive yield per plot was differed significantly and gave the greatest value of yield per plant (24.56 and 24.72 kg/plot in both two seasons respectively) when grown endive at 15cm spacing among plants, meanwhile the least value of yield per plot (18.16 and 19.39kg/plot) was recorded with plants which growing at 20cm among plants in both two growing seasons respectively. The relation between transplanting dates and spacing presented in Table 4. Data shown that there were significant differences between transplanting dates and spacing. The maximum value of yield per plant (26.06 and 26.82kg/plot) in both two seasons respectively was obtained from planting endive at 15th October with 15cm among plants each other's, while the minimum value (16.54 and 16.85kg/plot) was recorded with plants which planted in 15th December at 20cm spacing among plants in both two experimental seasons respectively.

Table 1 Effect of planting dates and spacing on plant length and leaves number per plant of endive plants during 2012/2013 and 2013/2014 seasons

Spacing	Dates	Plant length (cm)			Leaves number/plant		
		1st season	2nd season	Mean	1st season	2nd season	Mean
10cm	October 15th	32.65	34.96	33.81	55.11	61.97	58.54
	November 15th	30.92	32.25	31.59	49.65	54.96	52.31
	December 15th	27.07	27.67	27.37	46.21	49.18	47.7
	Mean	30.21	31.63	30.92	50.32	55.37	52.85
15cm	October 15th	34.96	35.95	35.46	60.43	65.47	62.95
	November 15th	34.08	34.2	34.14	54.11	57.05	55.58
	December 15th	29.32	29.92	29.62	49.77	51.77	50.77
	Mean	32.79	33.36	33.08	54.77	58.1	56.44
20cm	October 15th	37.68	39.03	38.36	66.81	69.26	68.04
	November 15th	36.78	35.93	36.36	59.23	60.43	59.83
	December 15th	30.46	31.21	30.84	55.11	55.88	55.5
	Mean	34.97	35.72	35.35	60.38	61.86	61.12
Mean of dates	October 15th	35.1	36.65	35.88	60.78	65.57	63.18
	November 15th	33.93	34.46	34.2	54.33	57.48	55.91
	December 15th	28.95	29.6	29.28	50.36	52.28	51.32
LSD at 5%	Spacing	1.03	1.09		0.47	0.69	
	Dates	1.03	1.09		0.47	0.69	
	Spacing X Dates	1.11	1.13		0.38	0.41	

Table 2 Effect of transplanting dates and spacing on ascorbic acid, dry weight, total sugars and inulin content of endive plants during 2012/2013 and 2013/2014 seasons

Spacing	Dates	Dry weight (g/100g)			Ascorbic acid (mg/100g)		
		1st season	2nd season	Mean	1st season	2nd season	Mean
10 cm	October 15th	5.89	6.01	5.95	19.96	21.31	20.64
	November 15th	5.55	5.66	5.61	18.83	20.06	19.45
	December 15th	4.84	4.95	4.9	16.27	16.65	16.46
	Mean	5.43	5.54	5.49	18.35	19.34	18.85
15 cm	October 15th	6.63	6.73	6.68	22.06	23.85	22.96
	November 15th	6.01	6.12	6.07	21.36	21.61	21.49
	December 15th	5.22	5.32	5.27	19.05	19.78	19.42
	Mean	5.95	6.06	6.01	20.82	21.75	21.29
20 cm	October 15th	7.06	7.17	7.12	20.98	22.54	21.76
	November 15th	6.66	6.76	6.71	20.11	20.93	20.52
	December 15th	5.81	5.91	5.86	17.34	17.89	17.62
	Mean	6.51	6.61	6.56	19.48	20.45	19.97
Mean of dates	October 15th	6.53	6.64	6.59	21	22.57	21.79
	November 15th	6.07	6.18	6.13	20.1	20.87	20.49
	December 15th	5.29	5.39	5.34	17.55	17.77	17.66
LSD at 5%	Spacing	0.05	0.07		0.26	0.35	
	Dates	0.05	0.07		0.26	0.35	
	SpacingX Dates	N.S	N.S		N.S	N.S	

Table 3 Effect of transplanting dates and spacing on total sugars % and inulin % contents of endive plants during 2012/2013 and 2013/2014 seasons

Spacing	Dates	Total sugars (%)			Inulin (%)		
		1st season	2nd season	Mean	1st season	2nd season	Mean
10 cm	October 15th	2.21	2.11	2.16	0.5	0.47	0.49
	November 15th	2.05	1.76	1.91	0.46	0.42	0.44
	December 15th	1.29	1.18	1.24	0.39	0.35	0.37
	Mean	1.85	1.68	1.77	0.45	0.41	0.43
15 cm	October 15th	2.49	2.41	2.45	0.62	0.6	0.61
	November 15th	2.24	2.23	2.24	0.55	0.52	0.54
	December 15th	1.58	1.63	1.61	0.49	0.47	0.48
	Mean	2.1	2.09	2.1	0.55	0.53	0.54
20 cm	October 15th	2.29	2.22	2.26	0.54	0.51	0.53
	November 15th	2.19	1.91	2.05	0.47	0.44	0.46
	December 15th	1.46	1.32	1.39	0.41	0.38	0.4
	Mean	1.98	1.82	1.9	0.47	0.44	0.46
Mean of dates	October 15th	2.33	2.25	2.29	0.55	0.53	0.54
	November 15th	2.16	1.97	2.07	0.49	0.46	0.48
	December 15th	1.44	1.38	1.41	0.43	0.4	0.42
LSD at 5%	Spacing	0.05	0.03		0.11	0.09	
	Dates	0.05	0.03		0.11	0.09	
	Spacing X Dates	0.02	0.04		N.S	N.S	

Table 4 Effect of transplanting dates and spacing on Fresh weight per rosette (g) and yield per plot (kg) of endive plants during 2012/2013 and 2013/2014 seasons

Spacing	Dates	Fresh weight per rosette (g)			Yield per plot (kg)		
		1st season	2nd season	Mean	1st season	2nd season	Mean
10 cm	October 15th	286.56	294.45	290.5	44.42	45.64	45
	November 15th	276.97	279.87	278.4	42.93	43.38	43.2
	December 15th	266.95	269.68	268.3	41.38	41.8	41.6
	Mean	276.83	281.33	279.1	42.91	43.61	43.3
15 cm	October 15th	440.54	444.75	442.6	46.26	46.7	46.5
	November 15th	433.45	437.65	435.6	45.51	45.95	45.7
	December 15th	426.64	429.97	428.3	44.8	45.15	45
	Mean	433.54	437.46	435.5	45.52	45.93	45.7
20 cm	October 15th	481.57	484.95	483.3	40.93	41.22	41.1
	November 15th	473.56	479.56	476.6	40.25	40.76	40.5
	December 15th	462.64	466.56	464.6	39.32	39.66	39.5
	Mean	472.59	477.62	475.1	40.17	40.6	40.4
Mean of dates	October 15th	402.89	408.05	405.5	43.87	44.52	44.2
	November 15th	394.66	399.03	396.8	42.9	43.36	43.1
	December 15th	385.41	388.74	387.1	41.83	42.2	42
LSD at 5%	Spacing	0.68	0.52		6.94	5.13	
	Dates	0.68	0.52		6.94	5.13	
	Spacing X Dates	0.83	0.71		5.15	2.09	

Discussions

Regarding to the highest values of plant length and leaves number per plant recorded with transplanting in October 15th with distance of 20cm. This might be attributed to the good weather conditions that promoted photosynthesis and improved growth on sugar beet.^{29,30} Also, it was noticed in lettuce the increase may be attributed to the low temperature during growth period. Temperature is the main factor determining the rate of growth during seedling emergence and the early growth period and low temperature during the vegetative growth at the initial stage, as the temperature was probably optimum to fulfill the vernalization requirement of the plants.^{9,10,31,32} The higher vegetative growth in the first date might be due to the better meteorological conditions, i.e., temperature, sunshine and day length of the compared with late transplanting dates. This superiority in vegetative growth might be also due to the narrow range of the difference between day and night temperatures in the first compared with late planting dates. These moderate conditions allow more photosynthesis and more metabolites reflecting better vegetative growth. In addition, suitable temperature for absorption and translocation of soil solution by the root system of broccoli.^{33–39}

Regarding to plant spacing, the increase in vegetative growth according to the increasing in the distance between plants might be due to less competition for nutrient, moisture and light intensity would be more in the case of high spacing. Accordingly, the less available nutrients under the conditions of high plant density would not allow for excessive rates of photosynthesis and accumulation of stored food in the leaves of plant.^{8,15,40} Additionally, one can infer that at the widest plant spacing there were more nutrients, light and moisture available per plant since plant density was at its lowest. The availability of more nutrients, moisture and light at the widest plant spacing possibly resulted in better growth characteristics. Contrastingly one can assume that at the closest plant spacing the availability of nutrients, light and moisture per plant was low since plant density was at its highest. One can infer that intraspecific competition was at its greatest at the closest spacing resulting in plants having the worst growth characteristics. It could be attributed to competition for photosynthetically active radiation and resources in closer plant spacing.⁴¹

The maximum values of ascorbic acid, dry weight, total sugar and inulin contents in leaves of endive plants were recorded with transplanting in October 15th with space of 15cm. Moreover, this was might be due to good weather which increase phytochemicals according to sowing time and growing conditions with high temperature and light intensity during vegetative growth resulted in vigorous growth, which enabled them to produce more yield of them. Vitamin C content is affected by seasonal factors such as sowing time and harvesting date.^{42,43} Branca⁴⁴ and Bianco⁴⁵ stated that *Eruca sativa* appeared to be rather rich in fibre, iron and particularly in Vitamin C than other leafy vegetables. Additionally, the amount of vitamin C was determined as 110mg 100g⁻¹ in rocket leaves and it is stated that this value was affected by sowing time and growing conditions. Esiyok et al.,⁴⁶ also found the value of Vitamin C in fall greater than the value of spring sowing time and therefore it is coherent with the findings of this study. Francke⁴⁷ on rocket reported that the shorter days and lower temperature provide high value of Vitamin C. In addition, this is concordant with the finding of fall sowing time in the research. According to Fraszczak et al.,⁴⁸ the length of day has the weakest effect on the content of Vitamin C in rocket; this explains well the decline of the Vitamin C content in spring sowing. This results were obtained by Ahmed⁴⁹ on broccoli. Increasing in vitamin

C was greatly related to the suitable prevailing temperature during the first transplanting date also to the increase in photosynthetic pigments and vegetative growth of plant⁵⁰ (on rocket). In the lower temperature the more dry matters were stored in the plants. This result suggested that the low temperature in growing period would help dry matters accumulation in the plants⁵¹ on curcifer vegetable). The increase with Oct transplanting in sugar content might be attributed to the good weather conditions that promoted photosynthesis and improved growth.^{29,30}

According to plant spacing, result showed that the highest value of ascorbic acid content obtained was recorded with distance of 15cm between plants. Our results are similar to Maul⁵² on tomato who reported that increasing light in to the plant leads to raised ascorbic acid. It can be concluded that more light to the crown of the plant was penetrated, which results in increased fruit ascorbic acid. Mahendran et al.,⁵³ reported that moisture stress reduced the ascorbic acid content of tomato fruits when the stress was imposed during the fruit ripening stage. It can be concluded that close spacing retains soil moisture. Also they stated a reduction in the D-glucose synthesis would have occurred during the period of stress, which in turn may have reduced the synthesis of ascorbic acid. Moisture stress may have reduced the substrate concentration for ascorbic acid synthesis. Reduction in the substrate may possibly be due to reduced photosynthetic rate.⁵³ These results were with the same trend of vegetative growth. Since the vegetative growth of the first transplanting date was higher, due to the higher photosynthetic surface might be wider. Consequently, metabolic activity of the first transplanting date plants would be better. More carbohydrates and other metabolites would be transformed to the leaves. Consequently, their chemical content became higher⁵⁴ (on kohlrabi).

Regarding to plant spacing, results exhibited that the greatest value of dry weight was recorded with distance of 20cm between plants. This increase in vegetative growth at wider spacing might be due to less competition for nutrient, moisture and light among the plants⁸ on lettuce. In case of wider spacing plant received enough light and space that leads to the attained maximum assimilation of nutrients that leads to attained highest dry matter content of plant²¹ (on lettuce). The greatest total sugar content in endive leaves according to planting space was recorded with distance of 15cm. It seems, that a higher light intensity may be result in a higher sugar content. Light response curves of leaf photosynthesis showed that photosynthesis and transpiration decreased from the top to the bottom of a sweet pepper canopy.⁵⁵ It is obvious that wider spacing allows plants to grow denser root system which enables plants to absorb more water and nutrients. In addition, the wide spacing enables plants to utilize better aeration and sunlight. Since the wide spacing plants are capable to utilize more natural resources, their vegetative growth might be vigorous and photosynthesis rate would be higher. Accumulation of the higher level of metabolites may increase dry weight, Vit. C and chemical content⁵⁴ (on kohlrabi). The maximum values of fresh weight per rosette and total yield per plant of endive plants were recorded by transplanting in October 15th. This may be attributed to the low temperature during November, December and January. Temperature is the main factor determining the rate of growth of lettuce during seedling emergence and the early growth period^{56,21,10,31,32} This finding is in agreement with the results of the paper as well⁵⁷ (on rocket). Abou-Hadid et al.,⁵⁸ stated that ecological temperatures as well as day length are the most important factors in controlling growth, yield and quality of lettuce. In the same regards, head weight of lettuce cultivars was clearly enhanced by extending day length to 14.5h especially during

winter and early spring plantings.⁵⁹ It also might be attributed to the good weather conditions that promoted photosynthesis and improved growth of sugar beet and hence increase root yield.^{29,30,60}

The reason of that decrease on late transplanting dates were high temperatures of following months which caused premature flowering in the case of 27% of the plants. This problem was also analyzed^{61,62} on chicory). The experiment considering planting dates of endive was conducted also by (Rodkiewicz, 2005). The author proved that in the conditions of the middle part of the Lublin region, it is possible to obtain a marketable yield of endive from sowing seeds from first decade of June till the middle of July. However, when seeds were sown in the first decade of June the yield of endive decreased. The reason of this was a tendency of cultivar 'Bossá' for premature flowering affected by the length of the day¹² (on endive). On the other hand, regarding to spacing treatments it was found that the highest fresh weight per rosette was obtained with distance of 20cm between plants in two growing seasons respectively. This was might be due to less competition for nutrient, moisture and light among the plants^{8,15} (on lettuce). In case of wider spacing plant receive enough light and space that leads to the attained maximum fresh weight of plant²¹ (on lettuce). The highest yield was obtained with distance of 15cm between plants in both seasons. The significant increase in yield at closer spacing over wider spacing may solely be ascribed on the function of highest plant density per unit area of land and accommodation of maximum number of plants (⁸on lettuce).

Conclusion

The maximum yield per plot was recorded from transplanting in October 15th and the minimum was recorded from transplanting in 15th December. The maximum yield per Fadden was recorded from planting with distance of 15cm between, while the minimum was recorded from planting at 20cm spacing between plants. So, planting in October 15th with distance of 15cm between plants may be used for endive plants.

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Conflict of interest

The author declares no conflict of interest.

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