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Influence of Sowing Time on Plant Growth and Production for some Varieties of Chard, in Western Part of Romania

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RESEARCH ARTICLE

Abstract
In Romania, chard is a less cultivated species, being present in some areas of Transylvania, on small areas. This research followed the results regarding chard growth and quantitative and qualitative production, obtained by growing plants in the specific conditions Western Romania. Experiment was bifactorial (5x2 type), with ten experimental variants. Comparative crops were carried out in summer and autumn, respectively, with differences in chard plants development (diameter of leaf rosette, length of leaves and petiole) and in the production achieved by varieties used in this research. For some experimental variants, the yields obtained were over 40 t/ha, being comparable to those obtained and mentioned in literature. Chard leaves content in dry matter as well as vitamin C was also monitored, results being comparable to those obtained in other growing conditions in Europe. Sowing time influenced chard total production, in summer crop being higher compared to autumn one. Also, dry matter and vitamin C content was influenced, crops harvested in autumn registered higher results regarding these traits.

Keywords: chard, cultivar, plant development, production, vitamin C, dry matter

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INTRODUCTION

Swiss chard (*Beta vulgaris* subsp. *cicla*) is member of *Chenopodiaceae* family and the genus *Beta* is endemic to the Old World (Bartsch et al., 1999). Beets for petiole, Swiss chard orchard, are grown for whole leaves or only for petiole, which are pleasant to taste, very fleshy, tender and juicy. Chard petioles and leaves can be eaten fresh, but most nutritionists recommend light thermal preparation to diminish the slightly bitter taste, but also to reduce the level of oxalates, which in large quantities can crystallize and create health problems such as kidney stones (Szilagyi et al., 2018). In Romania it is a less cultivated species, being present in some areas of Transylvania. Chard is considered a vegetable with vital impact in healthy eating, due to its high content of nutrients, especially vitamin C, vitamin E, folic acid, calcium, iron, and dietary fiber (Rana, 2016). Swiss chard should be considered a source of nutrients and phytochemicals (Maynard and Hochmuth, 1997; Bozokalfa et al., 2011, Gamba et al., 2021). Contents of N, P, K, Ca, and Mg in chard's leaves depended on nitrogen fertilizer type (Dzida and Pitura, 2008). Swiss chard has no fat, is low in calories and cholesterol (Drost, 2020). Cooked leaves yield 20 kcal per 100 g and are very nutritious (van Wyk, 2005, cited de

Maboko et. al., 2017). Some authors state that 100 g of chard is a good source of total chlorophyll-47,13 mg, carotenoids-9,85 mg, minerals as well as vitamin C-26,88 mg (Ivanović, L., et.al., 2019). Chard cultivars, which are yellow-orange and red-purple, are also a good source of carotenoids, in the form of provitamin A, which the body converts into vitamin A (Rana, 2016).

Swiss chard (*Beta vulgaris* L. var. *cicla* or *flavescens*) is a green leafy vegetable whose bioactive compounds have been studied due to its effects on health (Gamba et al., 2020). Research on the chemical composition, respectively the nutritional qualities of different types of chard, has highlighted the biological activities of the plant with regard to its anticancer, antidiabetic and antioxidant properties (Ninfali and Donato, 2013, Trifunovic et al., 2015). Chard is recommended in the diet of diabetics with a low content in carbohydrates and lipids, in anemia, spring asthenia and generally in nervous asthenia, having calming action (Oztay et al., 2015). In homeopathy, mangold juice is used in curing heart disease, is a good regulator of the intestinal tract, being recommended in fighting obesity (Gherman, 2013). Chard is widely spread in Turkey and used as an antidiabetic in traditional medicine (Sacan and Refiye, 2010). Beta vulgaris, var. cicla contains apigenin flavonoids, namely vitexin, vitexin-2-O-rhamnoside and vitexin-2-O-xyloside, which show antiproliferative activity on cancer cell lines (Ninfali and Donato, 2013).

Chard has a special economic importance, being cultivated on all continents, on large areas, allowing yields of about 40 t / ha (leaves with petioles). The crop is relatively accessible to producers, the cost price varies depending on the cost of seeds, herbicides, fertilizers, substances for disease and pest control, the use of labor for technological works as well as the degree of mechanization of works (Ciofu et al., 2004).

Chard is considered a vegetable species with a short vegetation period, being ready for harvesting after 60-70 days after emergence, which allows use in rotations, in summer or autumn crops (Kalota et al., 2010).

The aim of the research was to establish how some chard cultivars behave, in summer and autumn crops, respectively. Plant growth, petiole production and total production as well as dry matter and vitamin C content were monitored.

MATERIALS AND METHODS

The current research took place in 2021 and 2022, in a vegetable farm, in Săcueni, located in the North of Bihor County, in Western part of Romania. In 2021, average annual temperature was 11.5 ^{0}C and in 2022, 12.2 ^{0}C. Annual rainfall recorded was 539.21 mm in 2021, respectively 516.36 mm in 2022, according to data recorded at the Săcueni Meteorological Station Table 1.

Table 1. Climate characterization of experimentation years (Săcueni meteorological station)

Spec	**Monthly values**												**Annual values**
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	
Year 2021													
Tm (°C)	1.8	3.7	5.4	9.2	15.0	22.1	24.3	21.2	16.6	10.4	6.0	1.7	11.5
P (mm)	67.83	35.04	28.45	43.41	66.81	7.62	83.56	40.13	22.61	12.44	55.12	76.19	539.21
Year 2022													
Tm (°C)	-0.5	4.5	5.4	9.7	17.5	22.7	23.8	23.7	15.9	12.8	7.0	3.7	12.2
P (mm)	22.35	15.74	5.08	64.02	14.47	38.35	38.36	40.13	135.15	6.61	65.49	70.11	516.36

Tm- average temperature, P- total precipitations

Soil on which the experiment was placed was alluvial, with a morphological profile of the Ao-AC-CN type. From a physical point of view, the soil in the experimental area has the following characteristics: clay content (0,002 mm) 16,4-19,1; total porosity value, large-51; low apparent density, 1,25 g/cmc; permeability per profile, high - 18 mm/h; useful edaphic volume, large-100. Chemically, the soil had the following characteristics: soil reaction, weakly acidic, pH 5.95-6.4, throughout the profile; humus content, small 1.14-1.51; total nitrogen content, low 0,075; mobile phosphorus content, small 12 ppm; mobile potassium content, very low 60 ppm.

Chard cultivars Carde Blanche d'Ampuis, Liscia Verde da Taglio, Verte a Carde Blanche, Lucullus and Couleurs Rainbow were studied.

Carde blanche Ampuis is a variety with a petiole of 35-45 cm long and 10-12 cm wide, with a fine leaf of dark green color, of small size. It is an early, vigorous variety, resistant to cold and premature emission of floriferous stems.

Liscia Verde da Taglio is a variety with medium-sized green leaves, slightly embossed, with a short petiole. This variety is consumed just like spinach, in salads or cooked. It can be grown all year round, except during very cold periods.

Verte a carde blanche has light-colored, embossed leaves. The wide petiole is very cold-resistant and can be grown in the northern regions.

Lucullus is an early variety with a deeply embossed foliage, with white petiole. Leaves and petiole have an exceptional taste.

Couleurs Rainbow is a variety in which plants have vertical port, petioles of different colours (pink, white, yellow, orange) and dark green leaves. It takes 60 days to harvest the first leaves.

Establishment of chard culture was carried out by direct sowing on 28.04.2021 and 29.04.2022, for summer crop, respectively on 10.06.2021 and 12.06.2022, for autumn crop. Combining the two experimental factors (cultivar x culture period) resulted in 10 experimental variants, which were placed in three repetitions.

Conventional technology, specific to direct sowing culture, has been applied. Sowing distances 60 cm between rows and 30 cm between plants. During the growing season, development degree and plant growth (plant height, leaf rosette diameter, number of leaves, leaf length, length and thickness of petiole) and realized production (total production, production of petioles) were determined. After harvesting, determinations of dry matter and concentration in water were carried out using gravimetric method (using an analytical balance, hot-air oven for drying and Erlenmeyer Flasks for measurements), as well as the content of leaves in vitamin C (using chemical methods based on the reducing property of ascorbic acid, i.e., titrimetric method, using a HI931 automatic potentiometric titrator). For each determination, three tests corresponding to the three repetitions practiced in the experimental culture were performed. For the calculation and interpretation of the results, Fishers least significant difference test was used, obtained results were processed by analysing the bifactorial variance, on the main analysed characters. Average data of experimental years 2021 and 2022 is presented in this manuscript.

RESULTS AND DISCUSSIONS

Chard plant growth, 60 days after emergence, was higher on summer crop compared to autumn. Thus, leaf rosette diameter averaged 80.78 cm for summer crop, compared to 58.86 cm for autumn crop Table 2. Average leaf length recorded average values of 46.82 cm for summer crop and 27.05 cm for autumn crop. Petiole length was with 5.84 cm higher in summer crop. Plant growth recorded higher values at Lucullus variety, with leaf rosette diameter of 87.26 cm in summer crop and 65.50 cm in autumn crop. Average leaf length was 49.15 cm in summer crop and 27.70 cm in autumn crop, and petiole length was 6.67 cm longer in summer crop compared to autumn one.

Table 2. Grow rate of chard plants, 60 days after emergence
(average for 2021-2022)

Variant	Leaf rosette diameter (cm)			Leaf length (cm)			Petiole length (cm)		
	Cv	Ct	Cv-Ct	Cv	Ct	Cv-Ct	Cv	Ct	Cv-Ct
Carde Blanche d'Ampuis	78.40	55.45	22.95	43.35	27.22	16.13	15.65	10.03	5.62
Liscia Verde da Taglio	71.35	56.14	15.21	44.10	26.45	17.65	17.20	12.42	4.78
Verte a Carde Blanche	81.17	53.75	27.42	49.72	25.51	24.21	15.93	9.74	6.19
Lucullus	87.26	65.50	21.76	49.15	27.70	21.45	17.42	10.75	6.67
Couleurs Rainbow	85.72	63.46	22.26	47.80	28.36	19.44	16.75	10.82	5.93
Average	80.78	58.86	21.92	46.82	27.05	19.77	16.59	10.75	5.84

Cv- summer crop; Ct- autumn crop

Total production ranged from 33.21 t/ha for Liscia Verde da Taglio to 42.53 t/ha for Lucullus Table 3. Compared to research average, Lucullus variety achieved a higher yield by 9,38 %, difference in production being statistically

significant. Liscia Verde da Taglio variety recorded the lowest yield, difference compared to research average being very significantly negative. Production was above research average for Verte a Carde Blanche and Couleurs Raibow cultivars, difference in production not being statistically assured.

Simillar results were obtained by Topalovic A et. Al in 2018, chard growth rate and production was favorable for summer crops, compared to autumn ones.

Total production was higher compared to that obtained at Lucullus variety by other authors. Higher total (36.5 t ha^{-1}) and marketable (34.0 t ha^{-1}) yields were recorded for chard cv. Lucullus by Martyniak-Przybyszewska, 2005.

Table 3. Unilateral influence of cultivar on total chard production (average for 2021-2022)

Cultivar	Production		Difference to control (t/ha)	Significance
	t/ha	%		
Carde Blanche d'Ampuis	37.57	96.63	-1.31	-
Liscia Verde da Taglio	33.21	85.41	-5.67	000
Verte a Carde Blanche	40.47	104.08	1.69	-
Lucullus	42.53	109.38	3.65	x
Couleurs Rainbow	40.65	104.55	1.77	-
Average (control)	38.88	100.00	-	-

LSD P 5% 2,27 t/ha; LSD P 1% 3,78 t/ha; LSD P 0,1% 5,10 t/ha;
Legend for Statistical significance: (-) – insignificant, (ooo) - very significant negative, (x) - significantly positive.

On average, production was 45.74 t/ha for the summer crop and 32.83 t/ha for autumn crop respectively Table 4. Compared to research average, production achieved in summer crop was 16.44% higher, the difference in production being distinctly significant.

In Poland, significantly higher yields for all tested cultivars obtained in summer crops (61.74 t/ha) in comparison to autumn ones (30.64 t/ha) may be explained by better solar radiation conditions (Kołota et. al., 2010). Pokluda and Kuben (2002) obtained, in an experience with 13 cultivars, yields ranging from 16 t/ha (Cerveny variety) to 52 t/ha (Gator variety).

Table 4. Unilateral influence of crop period on chard production (average for 2021-2022)

Crop period	Production		Difference to control (t/ha)	Significance
	t/ha	%		
Summer crop	45.74	116.44	6.46	xx
Autumn crop	32.83	83.57	6.45	00
Average (control)	39.28	100.00	-	-

LSD P 5% 2,85 t/ha; LSD P 1% 4,68 t/ha; LSD P 0,1% 6,52 t/ha;
Legend for Statistical significance: (-) – insignificant, (oo) - distinctly significant negative, (xx) - distinctly significant positive

Maximum yield of 49.75 t/ha was recorded for Lucullus in summer crop, followed by Couleurs Rainbow, with 47.61 t/ha Table 5. In autumn crop, Lucullus variety registered 35.32 t/ha, followed by Verte a Carde Blanche variety with 34.50 t/ha. Compared to experience average, Lucullus, Couleurs Rainbow and Verte a Carde Blanche varieties showed very significant production differences. The Carde Blanche d'Ampuis variety, grown in summer, showed distinctly significant yield differences compared to experience average. In autumn crop, all cultivars achieved yields of over 30 t/ha, highest production of 35.32 t/ha being obtained for Lucullus variety.

Some authors obtained yields of 57.44 t/ha in spring crop and 29.18 t/ha in autumn crop for Lucullus variety. On average, Lucullus, Green White, Ribbed, Vulcan, Bresanne, Green Silver varieties achieved 61.74 t/ha in spring crop, 30.64 t/ha in autumn crop, the average being 46.19 t/ha (Kołota et. al., 2010).

Table 5. Combined influence of cultivar and crop period on chard production (average for 2021-2022)

Variant		Production		Difference to control (t/ha)	Significance
Cultivar	**Crop period**	**t/ha**	**%**		
Carde Blanche d'Ampuis	Summer	49.19	114.78	5.81	xx
	Autumn	30.04	76.45	-9.25	000
Liscia Verde da Taglio	Summer	39.80	101.29	0.51	-
	Autumn	30.63	77.95	-8.66	000
Verte a Carde Blanche	Summer	46.45	118.22	7.16	xxx
	Autumn	34.50	87.80	-4.79	00
Lucullus	Summer	49.75	126.62	10.46	xxx
	Autumn	35.32	89.89	-3.39	0
Couleurs Rainbow	Summer	47.61	121.17	8.32	xxx
	Autumn	33.70	85.77	-5.59	00
Average (control)		39.70	100.00	-	-

LSD P 5% 2,85 t/ha; LSD P 1% 4,52 t/ha; LSD P 0,1% 6,27 t/ha;
Legend for Statistical significance: (-) – insignificant, (o) - significantly negative, (oo) - distinctly significant negative, (ooo) - very significant negative, (x) - significantly positive, (xx) - distinctly significant positive, (xxx) - very significant positive.

Plant content in DM (dry matter) and vitamin C was higher in mangold plants from autumn crops in all varieties used in the experiment Table 6.

Table 6. Cultivar and crop period influence on chard plant content in dry matter and vitamin C (average for 2021-2022)

Variant		Content in dry matter (%)			Leaf content in vitamin C	
Cultivar	**Crop period**	**Leaves**	**Petiole**	**Average**	**mg/100 g.f.s**	**% compared to average summer/autumn**
Carde Blanche d'Ampuis	Summer	12.47	7.50	9.98	37.21	102.28
	Autumn	14.12	8.85	11.48	62.84	103.71
	Average	13.29	8.17	10.73	50.02	-
Liscia Verde da Taglio	Summer	13.05	7.63	10.34	34.85	95.79
	Autumn	14.38	8.77	11.57	55.23	91.15
	Average	13.71	8.20	10.95	45.04	-
Verte a Carde Blanche	Summer	12.71	7.32	10.01	33.12	91.03
	Autumn	13.46	8.45	10.95	56.73	93.62
	Average	13.08	7.88	10.48	44.92	-
Lucullus	Summer	13.28	8.64	10.96	39.88	109.62
	Autumn	15.02	10.23	12.62	64.76	106.88
	Average	14.15	9.43	11.79	52.32	-
Couleurs Rainbow	Summer	13.94	9.07	11.50	36.85	101.29
	Autumn	14.88	10.35	12.61	63.43	104.68
	Average	14.41	9.71	12.05	50.14	-
Average for summer crop		13.09	8.03	10.37	36.38	100.00
Average for autumn crop		14.37	9.33	11.86	60.59	100.00

Dry matter (DM) content in leaves averaged 13.09% in summer crop and 14.37% in autumn crop. DM content in leaves was higher for Couleurs Rainbow variety, 14.41% on average, followed by Lucullus variety, 14.15%. In leaf petiole, DM content was lower, average for summer crop being 8.03% and 9.33% respectively for autumn crop. Couleurs Rainbow variety recorded a higher DM content, with a average between leaves and leaf petiole content of 12.05 %, Table 6.

In similar experiences, Lucullus, Green White, Ribbed, Vulcan, Bresanne, Green Silver varieties had, on average, a dry matter content in leaves of 11.62% in spring crop and 13.96% in autumn crop, average being 12.79%. In leaf petiole, the content was 6.93% in spring crop and 8.54% in autumn one, respectively, the average being 7.73% (Kołota et al., 2010). Bozokalfa et al. (2016), determined the dry matter content of 52 mangold cultivars, the minimum value being 9.02%, the maximum value was 18.53% and the average was 10.89%.

Chard leaf content in vitamin C averaged 36.38 mg/100 g of fresh substance (g.f.s) for the summer crop and 60.59 mg/100 g.f.s for autumn crop. In summer crop, vitamin C content was between 33.12 mg/100 g.f.s for Verte a Carde Blanche variety and 39.88 mg/100 g.f.s for Lucullus variety. In autumn crop, vitamin C content was between 55.23 mg/100 g.f.s for Liscia Verde da Taglio variety and 64.76 mg/100 g.f.s for Lucullus variety. Compared to experiment average, Lucullus variety had an extra vitamin C content, of 9.62% for summer crop and 6.88% for autumn crop, respectively Table 6.

In other experiments, Lucullus, Green White, Ribbed, Vulcan, Bresanne, Green Silver varieties had, on average, a vitamin C content of 37.15 mg/100g^{-1} f.w. in spring crop, 60.12 mg/100g^{-1} f.w. the average being 48.64 mg/100g^{-1} f.w. Luculus variety had a content of 34.03 mg/100g^{-1} f.w. in spring crop and 64.60 mg·100g^{-1} f.w. in autumn crop (Kołota et al., 2010). Rioba et al. (2020) determined for Giant Fordhork variety, vitamin C content values between 14.56% and 32.46%, depending on the type of fertilizer administered and the dose used.

CONCLUSIONS

Chard plant growth, 60 days after emergence, was favorable on summer crops compared to autumn. Plant growth recorded higher values at Lucullus variety, where leaf rosette diameter was 87.26 cm in summer crop and 65.50 cm in autumn crop. Summer crops ensured higher yields compared to the autumn ones, for all cultivars. Maximum yield of 49.75 t/ha was recorded for Lucullus variety in summer crop, followed by Couleurs Rainbow, with 47.61 t/ha. In the autumn crop, the Lucullus variety registered 35.32 t / ha, followed by the Verte a Carde Blanche variety with 34.50 t / ha. The yields obtained in some variants were double compared to other results obtained in the same experimental area.

In autumn crop, chard plants accumulated more DM and had a higher content of vitamin C. Leaf dry matter content was higher at Couleurs Rainbow variety, with an average of 14.41%, followed by the Lucullus variety, with 14.15%. Petiole dry matter content was lower, average for summer crop being 8.03% and 9.33% respectively for autumn crop. Chard leaf content in vitamin C averaged 36.38 mg/100 g.f.s. for summer crop and 60.59 mg/100 g.f.s. for autumn crop. Couleurs Rainbow variety recorded a higher dry matter content, with an average between leaf and petiole content of 12.05 %.

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Conflicts of Interest

The authors declare that they do not have any conflict of interest.

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