INFLUENCE OF CULTIVAR AND DENSITY ON PLANT GROWTH AND PRODUCTION OF SWISS CHARD (*Beta vulgaris*, subsp. *cicla*), IN WESTERN ROMANIA

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Abstract. In Romania, Swiss chard is a less cultivated species, being present in some areas of Transylvania, on small surfaces. This research paper presents the results regarding the growth and the productions of Swiss chard, quantitative and qualitative, obtained in the specific conditions of western Romania. Purpose of the research was to establish how some Swiss chard cultivars behave, under different density conditions. Experiment was bifactorial, (3x4 type), with 12 experimental variants. Comparative crops were carried out in the summer-autumn period, with differences in growth of Swiss chard plants (plant height, petiole length and thickness) as well as in production, at different densities. For some experimental variants, yields obtained were over 50 t/ha, being comparable to those obtained and mentioned in the literature. Content of mangold leaves in dry matter as well as in vitamin C was also measured, the results being comparable to those obtained in other growing conditions in Europe.

Keywords: cultivar, density, petiole lenght and thikness, dry matter and vitamin C.

INTRODUCTION

Swiss chard (*Beta vulgaris* subsp. *cicla*) is member of *Amaranthaceae* family and the genus *Beta,* is native to the coasts of the Mediterranean basin (Libutti et al., 2023). Beets for petiole, or Swiss chard, are grown for whole leaves or only for petiole, which is pleasant to taste, very fleshy, tender and juicy. Beets for petioles and leaves can be eaten fresh, but most nutritionists recommend light thermal preparation to reduce 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.

Swiss chard is considered a vegetable with a vital impact on healthy eating, due to the rich content of the leaves in nutrients, especially vitamin C, vitamin E, folate, 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 Swiss chard's leaves depended on nitrogen fertilizer type (Dzida and Pitura, 2008, Petrova and Mitrova, 2023). Mangold cultivars that are yellow-orange and red-purple are also a good source of carotenoid substances, in the form of provitamin A, which the body converts into vitamin A (Rana, 2016).

Leaf has some specific roles, including capturing sunlight, absorbing CO_2, controlling inner temperature, and synthesizing carbohydrate. Leaves also very significantly contribute to quality of environment. Furthermore, vibrant colors of leaf blade and petiole, such as in Swiss chard plant, also contribute to aesthetic value in urban living space (Lakitan et.al., 2023). Color-full plants in urban green spaces were seen as more attractive and preferred by urban park users (Rahnema et al., 2019).

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., 2021).

Research on the chemical composition, respectively the nutritional qualities of different types of Swiss chard, has highlighted the biological activities of the plant regarding its anticancer, antidiabetic and antioxidant properties (Ninfali and Donato, 2013, Trifunovic et al., 2015). Swiss chard is recommended in the diet of diabetics with a low carbohydrate and lipid content, in anemia, spring asthenia and in general in nervous asthenia, having a calming action (Oztay et al., 2015). In homeopathy, Swiss chard juice is used to cure heart disease, is a good regulator of the intestinal tract, and is recommended in combating obesity (Gherman, 2013). Chard is widely spread in Turkey and used as an antidiabetic in traditional medicine (Sacan and Refiye, 2010).

Swiss chard has a special economic importance as it is cultivated on all continents, on large surfaces, allowing to obtain productions of about 40 t/ha (leaves with petioles). The crop is relatively accessible to producers, the cost price varying depending on the cost of seed, herbicides, fertilizers, substances to fight diseases and pests, the use of labor for technological works as well as the degree of mechanization of the works (Ciofu et al., 2004). Swiss chard is considered a vegetable species with a short vegetation period, being ready for harvest after 60-70 days after emergence, which allows it to be used in crop rotations, in summer or autumn crops (Kalota et al., 2010).

The purpose of the research was to establish how some Swiss chard crops behave, ensuring different thicknesses, in summer-autumn crop. Plant growth, total production as well as dry matter and vitamin C content were measured.

MATERIALS AND METHODS

The experiences took place in 2021 and 2022, in a vegetable farm in Săcueni, located in the north of Bihor County, in the western part of Romania. In 2021, the 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 the data recorded at the Săcueni Meteorological Station (table 1).

Table 1. Climatic characterization of the years of experimentation (Săcueni Meteorological Station)

Characters	Monthly values											Anual values
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Year 2021												
Tm (^{o}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 (oC)	-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	38,86	40,13	135,15	6,61	65,49	70,11	516,36

Tm- average temperature, P- total precipitations

The soil on which the experiment was placed was of alluvial type, with a morphological profile of Ao-AC-Cn type. From a physical point of view, soil in the experimental area has the following characteristics: clay content (0.002 mm) 16.4-19.1; total porosity value, high-51; bulk density, small - 1.25 g/cmc; permeability on the profile, high - 18 mm/h; useful edaphic volume, large - 100. From a chemical point of view, the soil had the following characteristics: soil reaction, slightly acidic, pH 5.95-6.4, throughout the profile; humus content, small 1.14-1.51; total nitrogen content, small 0.075; mobile phosphorus content, small 12 ppm; Mobile potassium content, very low 60 ppm.

In the experiments, cultivars Carde Blanche d'Ampuis, Lucullus and Couleurs Rainbow were used, which were cultivated at densities of 35.7-40.8-47.6-57.1 thousand plants/ha. Crop was established by direct sowing on April 28 and June 29, respectively, at a distance of 0.70 cm between rows. After plants emergence, the thinning of the plants was carried out at distances of 0.25-0.30-0.35-0.40 cm in order to achieve the proposed densities.

Carde Blanche d,Ampuis is a variety with a well-developed petiole, with a fine, dark green blade. It is an early, vigorous variety, resistant to cold and premature emission of flowering stems. Lucullus is an early variety with a deeply embossed foliage with a white petiole. The leaves and petiole are of exceptional taste quality. Couleurs Rainbow is a variety in which the plants have a vertical habit, petioles of different colors (pink, white, yellow, orange) and the leaf blade of dark green. Until the first leaves are harvested, 60 days are needed. By combining the two experimental factors (cultivar x density) resulted in 12 experimental variants, which were placed in three replicates.

During the research, conventional technology was applied, specific to the cultivation by direct sowing. During the vegetation period, the degree of plant development and growth (plant height, petiole length and thickness) and the production achieved were determined. After harvesting, determinations were made regarding the dry matter and concentration in water, using the gravimetric method (using an analytical balance, oven, ampoules for weighing), as well as the content of the leaves in vitamin C, (using the chemical method based on the reducing property of ascorbic acid, respectively the titrimetric method, using an automatic potentiometric titrator HI931).

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, current statistical methods were used (the processing of the production results was carried out by the method of analysis of variance, applied to bifactorial experiments based on the method of subdivided plots). The paper presents the average data of the experimental years 2021 and 2022.

RESULTS AND DISCUSSIONS

Growth of Swiss chard plants, 30 days from emergence, was on average between 18.22 cm for Carde Blanche d'Ampuis variety and 21.92 cm for Couleurs Rainbow variety (Table 2). At Couleurs Rainbow variety, plant height was between 20.4 cm at the density of 35.7 thousand plants/ha and respectively 23.9 cm at the density of 42.6 thousand plants/ha. Increase in plant density determined, at the beginning of the vegetation period, slight increase in plant height at all experimental varieties. After 60 days from emergence, plant height was higher at Lucullus variety (54.35 cm), average daily growth rate of the plants being 1.14 cm. In one-month period (between 30 and 60 days after emergence) Swiss chard plants grew by an average of 27.6 cm and 39.3 cm, depending on the variety and the density of the plants. Plant growth was more pronounced at the density of 35.7 thousand plants/ha, had an average daily rhythm of 1.31 cm. Pokluda and Kuben (2002) determined plant height in 13 Swiss chard cultivars for which the values were between 425 mm (Charlote) and 579 mm (Swiss Chard-Kings).

Table 2. Influence of cultivar and plant density on the growth of Swiss chard plants (average for 2021-2022)

Variant		Plant height (cm) after:			Average daily pace (cm)
Cultivar	Density (thousand plants /ha)	30 days	60 days	Difference	
Carde Blanche d'Ampuis	35.7	16.5	53.2	36.7	1.22
	40.8	17.3	54.7	37.4	1.25
	47.6	18.7	49.6	30.9	1.03
	57.1	20.4	48.3	279	0.93
	Average	18.22	51.45	33.23	1.10
Lucullus	35.7	18.2	57.5	39.3	1.31
	40.8	19.7	55.8	36.1	1.20
	47.6	20.5	53.2	32.7	1.09
	57.1	21.8	50.9	29.1	0.97
	Average	20.05	54.35	34.3	1.14
Couleurs Rainbow	35.7	20.4	53.8	33.4	1.11
	40.8	21.3	51.4	30.1	1.00
	47.6	23.9	52.0	28.1	0.94
	57.1	22.1	49.7	27.6	0.92
	Average	21.92	51.72	29.8	0.99

Determinations made 60 days from the emergence, on the degree of development of leaf petiole showed that experimental factors influenced its growth (Table 3). Petiole length was on average longer for Couleurs Rainbow variety (16.1 cm), ranging from 14.2 cm, at a density of 57.1 thousand plants/ha and 17.9 cm at a density of 35.7 thousand plants/ha, respectively. At all varieties, lower plant density (35.7 thousand plants/ha, 40.8 thousand plants/ha) ensured a better petiole development, which had a longer length by 2.1-14.1% compared to the average. Petiole thickness was on average higher for Lucullus variety, 3.3 cm with limits between 2.5

cm at the density of 57.1 thousand plants/ha, respectively 4.1 cm at the density of 35.7 thousand plants/ha. Growing plants at greater distances per row ensured a better petiole development so that at the density of 35.7 thousand plants/ha, petiole thickness was 22.5-28.6% higher compared to the average and at the density of 40.8 thousand plants/ha the petiole thickness was 6.5-10.7% above the average of the four densities. Ensuring distances between plants in a row of 35-40 cm determined a better petiole development in all three varieties used in the experiment. density of 57.1 thousand plants/ha negatively influenced the petiole development in all varieties, petiole length and thickness registering the lowest values.

Table 3. Influence of cultivar and density of Swiss chard plants on petiole development, 60 days from emergence (average for 2021-2022)

Variant		Petiole lenght		Petiole thickness	
Cultivar	Density (thousand plants /ha)	cm	%	cm	%
Carde Blanche d'Ampuis	35.7	15.7	108.3	3.6	128.6
	40.8	14.8	102.1	3.1	110.7
	47.6	14.1	97.2	2.7	96.4
	57.1	13.4	92.4	2.0	71.4
	Average	14.5	100.0	2.8	100.0
Lucullus	35.7	16.2	114.1	4.1	124.2
	40.8	14.9	104.9	3.6	109.1
	47.6	13.3	93.7	3.0	90.9
	57.1	12.5	88.0	2.5	75.8
	Average	14.2	100.0	3.3	100.0
Couleurs Rainbow	35.7	17.9	111.2	3.8	122.5
	40.8	16.5	102.5	3.3	106.5
	47.6	15.7	97.5	2.9	93.5
	57.1	14.2	88.2	2.2	70.9
	Average	16.1	100.0	3.1	100.0

Table 4. Influence of cultivar and plant density on the dynamics of Swiss chard production (average for 2021-2022)

Variant		Harvesting period (decade/month), t/ha						Total production t/ha
Cultivar	Density (thousand plants /ha)	II/07	I/08	II/08	II/09	III/10	II/11	
Carde Blanche d'Ampuis	35.7	3.60	5.12	8.33	9.14	7.45	5.10	38.74
	40.8	4.85	6.37	9.64	10.53	8.12	7.06	46.57
	47.6	5.30	7.05	9.87	10.72	9.91	7.21	50.06
	57.1	4.75	6.82	8.58	9.07	7.35	6.74	43.31
Lucullus	Average	4.15	5.76	9.92	10.25	9.74	6.91	46.73
	35.7	5.23	7.90	11.43	13.14	11.25	7.22	56.17
	40.8	5.62	7.44	10.25	12.43	10.04	7.36	53.14
	47.6	4.90	6.80	10.06	10.65	9.47	6.05	47.93
	57.1	4.01	5.30	8.45	9.74	8.02	6.71	42.23

Couleurs Rainbow	Average	4.53	6.14	9.32	11.25	9.74	7.22	48.20
	35.7	5.27	7.05	9.74	11.47	10.24	7.04	50.81
	40.8	4.82	6.72	8.97	10.22	8.37	6.35	45.55

Harvesting of swiss chard leaves began in the second decade of July and continued until the second decade of November, with 6 harvests being carried out during the growing season (Table 4). The volume of harvested production increased from the beginning of the harvest period until September, after which it decreased for all experimental variants. Experimental variants with densities of 40.8 thousand plants/ha and 47.6 thousand plants/ha respectively recorded a better production dynamics for all three varieties used in the experiment.

Varieties used in the experiment recorded, on average, a total production between 44,67 t/ha for Carde Blanche d'Ampuis variety and 51,04 t/ha for Lucullus variety (Table 5). Compared to the average, Lucullus variety recorded a production increase of 7.33%, the difference in production compared to control being significant. Pokluda and Kuben (2002) obtained, in an experiment with 13 cultivars, yields ranging from 16 t/ha (Cerveny variety) to 52 t/ha (Gator variety). Higher total (36.5 t ha^{-1}) and marketable (34.0 t ha^{-1}) yields were recorded for Lukullus variety (Martyniak-Przybyszewska, 2005). In Poland, significantly higher yields of all tested cultivars obtained in spring growing (61.74 t/ha) in comparison to the autumn season (30.64 t/ha) may be explained by better solar radiation conditions (Kołota et. al., 2010).

Table 5. Influence of cultivar on Swiss chard production
(average for 2021-2022)

Cultivar	Production		+_ Difference	Significance of
	t/ha	%	to control t/ha	difference
Carde Blanche d'Ampuis	44.67	93.94	-2.89	-
Lucullus	51.04	107.33	3.49	*
Couleurs Rainbow	46.96	98.75	-0.59	-
Average (control)	47.55	100.00	0.00	-

LsD (P 5%) 3.35; Lsd (P 1%) 6.72 ; LsD (P 0.1%) 9.17
Legend for Statistical significance: (-) – insignificant (x) - significantly positive

Table 6. Influența desimii plantelor asupra producției de mangold (average for 2021-2022)

Plant density	Production		+_ Difference to	Significance of
(thousand plants /ha)	t/ha	%	control t/ha	difference
35.7	42.56	89.71	-4.88	o
40.8	50.31	106.05	2.87	-
47.6	51.33	108.19	3.89	*
57.1	45.59	96.10	-1.85	-
Average (control)	47,.44	100.00	0.00	-

LsD (P 5%) 3.62; LsD (P 1%) 6.85 ; LsD (P 0.1%) 10.04
Legend for Statistical significance: (-) – insignificant (x) - significantly positive

Unilateral influence of plant density on total production showed that the increase of plant density up to 47.6 thousand plants/ha determines the increase of production,

after which the increase of the density to 57.1 thousand plants/ha leads to its decrease (Table 6).

Production of Swiss chard was between 42.56 t/ha at the density of 35.7 thousand plants/ha and 51.33 t/ha at the density of 47.6 thousand plants/ha, where the production increase compared to experience average was 8.19%, the difference in production being statistically significant. A production above the average of experience was also recorded at a density of 40.8 thousand plants/ha, the production increase being 6.05%, the difference in production not being statistically ensured.

Table 7. Combined influence of cultivar and plant density on Swiss chard production (average for 2021-2022)

Variant		Production		+_	Significance
Cultivar	Density thousands pl/ha	t/ha	%	Difference to control t/ha	of difference
Carde Blanche d'Ampuis	35.7	38.74	86.72	-5.93	o
	40.8	46.57	104.25	1.90	-
	47.6	50.06	112.07	5.39	*
	57.1	43.31	96.95	-1.36	-
	Average(control)	44.67	100.00	0.00	-
Lucullus	35.7	46.73	95.49	-4.26	o
	40.8	56.17	110.16	5.18	*
	47.6	53.14	104.21	2.15	-
	57.1	47.93	94.00	-3.06	-
	Average(control)	50.99	100.00	0.00	-
Couleurs Rainbow	35.7	42.23	90.42	-4.47	o
	40.8	48.20	103.21	1.50	-
	47.6	50.81	108.80	4.11	*
	57.1	45.55	97.53	-1.15	-
	Average(control)	46.70	100.00	0.00	-

LsD (P 5%) 4.05; LsD (P 1%) 6.72 ; LsD (P 0.1%) 8.90
Legend for Statistical significance: (-) – insignificant, (o) - significantly negative, (x) - significantly positive,

Swiss chard production ranged from 38.74 t/ha at Carde Blanche d'Ampuis variety cultivated at a density of 35.7 thousand plants/ha and 56.17 t/ha recorded at Lucullus variety with a density of 40.8 thousand plants/ha (Table 7). From the combined influence of the two experimental factors resulted in the fact that at the density of 35.7 thousand plants/ha the production was lower for the three varieties, the differences in production compared to control variants being significantly negative. Lucullus variety obtained the maximum production of 56.17 t/ha at a density of 40.8 thousand plants/ha, the increase in control production being 10.16%. Varieties Carde Blanche d'Ampuis and Couleurs Rainbow obtained maximum yields at a density of 47.6 thousand plants/ha with a production increase of 8.8% to 12.07%, the differences in production being statistically significant. Lucullus variety at a density of 47.6 thousand plants/ha registered a production increase of 4.21%, the difference compared to control not being statistically ensured. The increase in plant density to 57.1 thousand

plants/ha determined the reduction of production in line with the average, differences in production not being statistically ensured.

At the beginning of harvest (July), dry matter content in leaf petiole averaged between 7.28 % for Carde Blanche d'Ampuis variety and 9.91 % for Couleurs Rainbow variety (Table 8). In variants with lower density, the content of D.M. in leaves petiole was slightly higher compared to that of the variants with higher densities. In autumn period (September), D.M. content in petiole was on average 1.13% higher (Carde Blanche d'Ampuis variety) and 1.70% higher (Lucullus variety). In leaf blade, D.M. content was higher compared to the values recorded in the petiole, so that in July the values were on average between 12.09% (Carde Blanche d'Ampuis variety) and 13.90% (Lucullus variety). In September, the content of D.M. recorded higher values, ranging from 14.11 % (Carde Blanche d'Ampuis variety) to 14.62 % (Lucullus variety). Between the two periods of determination of D.M. there were differences between 0.72 % (the Couleurs Rainbow variety at a density of 35.7 thousand plants/ha) and 2.13 % (the Carde Blanche d'Ampuis variety at a density of 40.8 thousand plants/ha).

Table 8. Influence of cultivar and plant density on the content of dry substance in Swiss chard (average for 2021-2022)

Variant		Dry matter content (%) in:					
Cultivar	Density thousands pl/ha	Leaf petiole			Leaf blade		
		July	September	Average	July	September	Average
Carde Blanche d'Ampuis	35.7	7.40	8.60	1.20	12.25	14.30	2.05
	40.8	7.43	8.55	1.12	12.14	14.27	2.13
	47.6	7.26	8.37	1.11	12.09	14.08	1.99
	57.1	7.05	8.12	1.07	11.88	13.79	1.91
	Average (control)	7.28	8.41	1.13	12.09	14.11	2.02
Lucullus	35.7	8.65	10.34	1.69	13.57	15.12	1.55
	40.8	8.71	10.29	1.58	13.38	15.21	1.83
	47.6	8.33	10.07	1.74	13.20	14.76	1.56
	57.1	8.04	9.83	1.79	12.85	14.28	1.43
	Average (control)	8.43	10.13	1.70	13.25	14.84	1.59
Couleurs Rainbow	35.7	9.02	10.45	1.43	13.90	14.62	0.72
	40.8	9.05	10.33	1.28	13.78	14.70	0.92
	47.6	8.87	10.18	1.31	13.44	14.51	1.07
	57.1	8.72	9.83	1.11	13.12	14.17	1.05
	Average (control)	8.91	10.19	1.28	13.56	14.50	0.94

Bozokalfa et al. (2016), determined D.M. content of 52 swiss chard varieties, minimum value being 9.02%, maximum value being 18.53% and the average was 10.89%. In similar experiments, the varieties Lukullus, Green White, Ribbed, Vulcan, Bresanne, Green Silver had, on average, a D.M. content in the leaf blade of 11.62 % in spring crops and 13.96 % in autumn crops, average being 12.79 %. In leaf petiole, the

content was 6.93 % in spring crops and 8.54 % in autumn crops, respectively, the average being 7.73% (Kołota et al., 2010).

Vitamin C content determined in leaf blade at the beginning of harvest period averaged 35.26 mg/100 g.f.m. for Carde Blanche d'Ampuis variety to 39.15 mg/100 g.f.m. for Lucullus variety (Table 9). In autumn, in September, vitamin C content was between 51.06 mg/100 g.f.m., for Carde Blanche d'Ampuis variety and 61.00 mg/100 g.f.m. for Lucullus variety, respectively. In leaf petiole, vitamin C content was higher in September with average values between 13.12 mg/100 g.f.m. for Couleurs Rainbow variety and 14.56 mg/100 g.f.m. for Lucullus variety.

Kolota and Czerniak (2010) determined the vitamin C content in leaf blades of Swiss chard, Lucullus variety, depending on N fertilization, reaching maximum values of 38.04 mg/100^{-1}g.f.m. at a dose of 150 kg N/ha. In other experiments, the varieties Lukullus, Green White, Ribbed, Vulcan, Bresanne, Green Silver had, on average, a vitamin C content of 37.15 mg/$100g^{-1}$ f.w. for the 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 the spring crop and 64.60 mg·$100g^{-1}$ f.w. in autumn crop (Kołota et al., 2017). Rioba et al. (2020) determined vitamin C content values between 14.56% and 32.46% in Giant Fordhork variety, depending on the type of fertilizer administered and the dose used.

Table 9. Influence of cultivar and plant density on Vitamin C content of Swiss chard (average for 2021-2022)

Variant		Vitamina C content (mg/100 g.f.m) in:					
Cultivar	Density thousands pl/ha	Leaf petiole			Leaf blade		
		July	September	Average	July	September	Average
Carde Blanche d'Ampuis	35.7	36.25	52.16	15.91	24.56	38.87	14.31
	40.8	36.02	51.77	15.75	24.78	38.51	13.73
	47.6	35.50	50.45	14.95	23.62	38.04	14.42
	57.1	33.27	49.93	16.66	23.27	37.80	14.53
Lucullus	35.7	39.80	61.72	21.92	25.08	39.65	14.57
	40.8	39.36	61.12	21.76	24.70	39.21	14.51
	47.6	39.01	60.79	21.78	24.85	39.03	14.18
	57.1	38.44	60.37	21.93	23.74	38.66	14.92
Couleurs Rainbow	35.7	37.92	57.42	19.50	25.00	38.39	13.39
	40.8	37.40	57.08	19.68	25.12	38.12	13.00
	47.6	36.73	56.77	20.04	24.65	37.58	12.93
	57.1	36.51	56.30	19.79	24.04	37.22	13.18

CONCLUSIONS

At all three varieties, smaller densities (35.7 thousand plants/ha, 40.8 thousand plants/ha) ensured a better development of petiole, which had a longer length by 2.1-14.1% compared to the average. Growing plants at greater distances in a row ensured a better petiole development so that at the density of 35.7 thousand plants/ha, petiole thickness was 22.5-28.6% higher compared to the average and at the density of 40.8

thousand plants/ha, petiole thickness was 6.5-10.7% above the average of the four densities.

Volume of harvested production increased from the beginning of the harvest period until September, after which it decreased for all experimental variants. Experimental variants with densities of 40.8 thousand plants/ha and 47.6 thousand plants/ha respectively recorded a better production dynamic for all three varieties used in the experiment.

Unilateral influence of plant density on total production showed that the increase of plant density up to 47.6 thousand plants/ha determines the increase of production, after which a density increase to 57.1 thousand plants/ha leads to its decrease. Lucullus variety obtained a maximum production of 56.17 t/ha at a density of 40.8 thousand plants/ha, production increase compared to control being 10.16%. Varieties Carde Blanche d'Ampuis and Couleurs Rainbow obtained maximum yields at a density of 47.6 thousand plants/ha with a production increase of 8.8% to 12.07%.

In autumn period (September), dry matter content in the petiole had on average values higher by 1.13% (Carde Blanche d'Ampuis variety) and 1.70% (Lucullus variety) compared to the beginning of the harvest period (July). Vitamin C content determined in the leaf blade at the beginning of the harvesting period averaged between 35.26 mg/100 g.f.m. for Carde Blanche d'Ampuis variety and 39.15 mg/100 g.f.m for Lucullus variety. In leaf petiole, vitamin C content was higher in September with average values between 13.12 mg/100 g.f.m. for Couleurs Rainbow variety and 14.56 mg/100 g.f.m for Lucullus variety.

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