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CULTIVATION OF SALAD ESCARIOLE CHICORY IN CONDITIONS OF CLIMATE CHANGE

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У статті узагальнено ефективність адаптивних елементів технології та віднайдено нові підходи у вирощуванні цикорію ескаріол і в подальшому дотримання оптимального строку сівби, що є досить актуальним для поширення, встановлення адаптивності культури та удосконалення технології вирощування цикорію салатного ескаріол в Правобережному Лісостепу України. Дослідження передбачали встановити оптимальний строк висіву насіння цикорію салатного ескаріол різних сортів та встановити його вплив на урожайність і якість продукції.

Ключові слова: *цикорій салатний, ескаріол, сорт, строк сівби, кількість листків, урожайність, якість.*

Introduction. The article is devoted to topical issues of cultivars' adaptability and improvement of the escarole growing technology in the Right-bank forest-steppe of Ukraine. To establish the optimal timeframe for escarole sowing, depending on cultivars, and to elucidate the effect of this factor on yield and product quality.

Under current conditions of constant price growth, sustainable harvesting of high, top-quality yields is impossible without knowledge of the biological characteristics of each cultivar or using scientifically sound cultivation technologies [1, 2, 12, 13]. The soil and climatic conditions differ significantly in different regions of Ukraine. In turn, this affects the determination of optimal parameters for escarole sowing. Thus, a well-chosen sowing period contributes to the emergence of even and uniform seedlings and ensures optimal onsets and completions of the phases of plants' growth and development and uniform technical ripeness of top-quality greens. Delayed sowing decreases the crop performance and quality [7, 12]. Combinations of these factors draw forth-Ukrainian producers' great interest in C. escarole; however, its wide implementation in production is limited by lack of state-of-art scientifically rationalized cultivation technologies.

Analysis of recent research and publications. Studies of agrobiological features of escarole plants, its growing technology elements, and responses of plants to growing conditions, low temperatures, and aridity to harvest high yields in the South of Ukraine have not been conducted. Such studies are vital for improving the assortment of plants, extending the period of fresh greens supply, and ensuring the food security of Ukraine as a whole [13, 16]. Sustainable harvest of high yields of

C. escarole, like in other agricultural crops, is determined by three factors: top-quality seeds, well-proven growing technologies and favorable weather [17]. The sowing period is one of the main elements of the C. escarole growing technology, because, even without minimal costs, it helps to increase the yield. The C. escarole sowing timeframe is determined by biological characteristics: seed germination at low soil temperatures and resistance of young plants to spring temperature drops [15, 21]. The physical soil maturity, which ensures the maximum germination of seeds in the field, is the main reference point for starting to sow C. escarole [9]. Many scientists demonstrated that a delay in sowing by only 5–8 days led to a shortfall in production of over 5.0 t/ha and deteriorated quality indicators [1, 23]. Due to more indepth research into this issue, it was found that sowing time was an effective method to influence the phenotype of plants, including growth, development, yield, and quality indicators. In addition, sowing time affected not only the C. escarole yield but also the product quality, meaning better use [22, 24, 25].

Therefore, elucidation of the optimal time for escarole sowing to harvest a higher top-quality yield in the Right-bank forest-steppe of Ukraine is an important and urgent objective. The study was intended to investigate the C. escarole sowing timeframes and to evaluate their effect on the yield of plants in the Forest Steppe of Ukraine. To accomplish this purpose, the corresponding objectives were set: to identify the optimal sowing period for escarole cultivars and to assess the effects of cultivars and sowing periods on the yield and quality.

Research methodology. The sowing period effect on the escarole yield was studied in the fields of the Uman National University of Horticulture in 2021–2023. Three sowing periods were tested: the second ten days of April (control), the first ten days of May, and the third ten days of May. The total area of the experimental plot was 15 m^2; the experiments were replicated four times. The following escarole cultivars were chosen for the study: 'Vohnyshche', 'Indigo', 'Palla Rosa', 'Red Ball', and 'Shcherbet'. Plants were sown according to a 45 × 20 cm scheme (110,000 plants/ha). The experiment was designed in four replications; the record plot area was 5 m^2. In order to control the C. endivia quality indicators in Ukraine, the UN ECE FFV-22 and UN ECE STANDARD FFV-38, 2017 were used. Phenological observations, biometric measurements, and physiological-biochemical analyses were conducted by conventional methods [6]. The data obtained were processed by analysis of variance in Agrostat.

Research results. The length of the "sowing-emergence" interphase period directly depends on sowing time. The emergence of seedlings, their evenness and uniformity are especially affected by weather, viz. fluctuations in the average daily temperature and water availability. In the scientific literature, there is little information about using different sowing timeframes for C. escarole. However, it was found that, upon pre-winter sowing of the crop, the earliest and evenest seedlings were obtained, they were less susceptible to frosts, and withstood fluctuations and drops in the air and soil temperatures well in the Western Forest-Steppe [2]. In our conditions, single seedlings of C. escarole emerged after 7–14 days of sowing within the second ten days of April. When C. escarole was sown within the second ten days of May, seedlings

emerged after 6–10 days. Upon sowing within the third ten days of May, seedlings emerged after 8 days. Earlier and evener seedlings were obtained by C. escarole sowing within the second ten days of May. Owing to this, the vegetation of plants sown within this period was longer, which had a positive effect on the yield. When C. escarole was sown within the third ten days of May, seedlings emerged after 8–10 days, it was 2–6 days earlier than upon the "second ten days of April" sowing. However, upon the "third ten days of May" sowing, seedlings were thinned, which can be explained by insufficient amounts of moisture in the soil and soil crust. The water content in the soil during the second ten days of May was 4–5 % lower than during the second ten days of April and amounted to 20–22 % of the minimum moistureholding capacity (MMHC). Mass emergence (75 %) was seen after a month upon all sowing periods. Complete germination was noted in June: June 7–10 upon the "second ten days of April" sowing, June 19–20 upon the "second ten days of May" sowing, and June 25–28 upon the "third ten days of May" sowing. Therefore, the soil temperature and moisture are important factors for the germination of escarole seeds and emergence of seedlings. As a result of sowing within the second and third ten days of May, more plants per unit area grew because of more favorable conditions. There were certain differences in major biometric parameters of plants of the studied cultivars sown in different periods. The total number of escarole leaves depended on the sowing timeframes and cultivars (Table 1).

Table 1. The number of escarole leaves depending on the sowing timeframes, leaves/plant

Cultivar (factor A)	Sowing time (factor B)	2021	2022	2023	Year Mean 2021–2023
Vohnyshche (C)	April, second ten days (C)*	25,9	25,3	26,1	25,8
	May, first ten days	27,8	27,2	26,7	27,2
	May, third ten days	26,6	27,3	26,9	26,9
Indigo	April, second ten days (K)*	31,1	30,1	26,5	29,2
	May, first ten days	27,2	28,6	28,3	28,0
	May, third ten days	26,3	35,5	32,4	31,4
Palla Rosa	April, second ten days (K)*	27,2	29,3	25,1	27,2
	May, first ten days	29,9	27,2	28,7	28,6
	May, third ten days	32,5	29,8	32,9	31,7
Red Ball	April, second ten days (K)*	27,1	29,5	25,8	27,5
	May, first ten days	26,5	33,2	32,5	30,7
	May, third ten days	30,5	31,2	31,8	31,2
Shcherbet	April, second ten days (K)*	28,9	30,0	28,5	29,1
	May, first ten days	29,6	29,8	32,5	30,6
	May, third ten days	32,2	30,8	31,0	31,3
LSD_{05} *total factor A* *factor B* *AB factor*		*2,5* *1,1* *1,4*	*2,2* *1,7* *1,6*	*1,6* *1,7* *1,4*	–

*Note – * (C) control*

Escarole cv. 'Vohnyshche' had the fewest leaves (25.8–27.2 leaves/plant) in the studied periods. Cvs. 'Red Ball', 'Indigo', 'Palla Rosa', and 'Shcherbet' had the greatest numbers of leaves when sown within the third ten days of May (31.2–31.7 leaves/plant). Fewer leaves were formed in the studied cultivars sown within the second ten days of April (25.8–29.2 leaves/plant). Upon late sowing, there were more leaves (26.9–31.7 leaves/plant) than in the control.

Analyzing the total number of leaves per plant depending on sowing time, we noted relatively few leaves after early sowing, which is largely related to the weather during the cultivation.

The water deficit and rather high temperature from the emergence of seedlings to the onset of the intensive growth phase upon late sowing affected the total number of leaves per plant. Thus, characterizing the main biometric characteristics, we noted that they were influenced by both varietal features of the cultivars under investigation and sowing time as well as by conditions of the study year. Analysis of the biometric measurements of escarole conducted at harvest showed that the number of leaves had a significant effect on the cultivars' performance and depended on sowing time in the study years. Evaluating the escarole plant weight, we noted significant variations in this parameter both between the cultivars and between the growing time in the study years. The weight of the studied escarole cultivars was 213–296 g. In general, during the research years, the escarole weight was 255 g in the control. Cvs. 'Vohnyshche' and 'Indigo' stood out with the highest weights of 272–296 g upon early sowing. Sown within the third ten days of May, cvs. 'Vohnyshche' and 'Palla Rosa' had greater weights of 258–275 g, significantly exceeding the control.

The obtained results can be explained by biological features of the cultivars since they form plants of different weights. Cvs. 'Palla Rosa' and 'Red Ball' form loose heads or semi-heads, which are in general smaller than the rosettes of leaves in the other studied cultivars. Estimation of the yields from the escarole cultivars under investigation showed that they depended on the assortment (factor A), sowing time (factor B), and growing conditions (Table 2).

Analyzing the yields in the research years, we noted a certain gain the the yields from escarole cvs. 'Vohnyshche' and 'Indigo' sown within the first ten days of May: they yielded 32.9 t/ha and 30.3 t/ha or 4.7 t/ha and 2.1 t/ha more than the control, respectively. The gain in the yields compared to the control was statistically significant as it was higher than LSD05 in the study years. The other cultivars yielded less than the control, regardless of the sowing timeframes.

The highest yields were harvested due to better wetting during the spring sowing period. Analyzing the chemical composition of commercial escarole products, we observed significant effects of the tested factors, in particular, sowing time and cultivar assortment, on the vitamin C content in leaves. The highest content of vitamin C (35.85 mg/100 g) was accumulated in C. escarole cv. 'Indigo' sown within the third ten days of May. Escarole cv. 'Palla Rosa' also accumulated the highest level of vitamin C 35.50 mg/100 g when sown in the same period.

Table 2. Yield of the escarole cultivars depending on sowing period time, t/ha

Cultivar (factor A)	Sowing time (factor B)	2021	2022	2023	Year Mean 2021–2023	± to control
Vohnyshche (C)	April, second ten days (C)*	26,9	28,4	29,4	28,2	0
	May, first ten days	32,4	31,8	34,5	32,9	4,7
	May, third ten days	33,9	33,1	24,5	30,5	2,3
Indigo	April, second ten days	28,3	28,1	29,8	28,7	0,5
	May, first ten days	32,2	32,9	25,7	30,3	2,1
	May, third ten days	23,5	23,1	24,3	23,6	-4,6
Palla Rosa	April, second ten days	22,8	25,0	28,9	26,8	-2,6
	May, first ten days	25,2	26,9	28,4	26,8	-1,4
	May, third ten days	28,6	27,6	29,5	28,6	0,4
Red Ball	April, second ten days	28,1	28,9	27,5	28,1	-0,1
	May, first ten days	28,7	27,1	28,5	28,2	0
	May, third ten days	20,5	29,1	27,6	25,7	-2,5
Shcherbet	April, second ten days	24,0	25,2	25,5	24,9	-3,3
	May, first ten days	24,7	25,1	26,3	25,4	-2,8
	May, third ten days	27,8	25,5	26,5	26,6	-1,6
LSD_{05}						
factor A		*2,05*	*2,41*	*2,66*	–	
factor B		*2,27*	*2,11*	*2,83*		
AB factor		*3,16*	*2,36*	*3,1 4*		

*Note – * (C) control*

The lowest levels of vitamin C were accumulated when the escarole cultivars were sown within the third ten days of May. In the study period, we observed a certain increase in the dry matter content in escarole leaves upon April sowing in comparison with May sowing. Among the tested escarole cultivars, the highest content of dry matter (7.91 %) was recorded for cv. 'Indigo'; the differences were confirmed by statistical calculations for both factor A (cultivar) and factor B (sowing time). The lowest content of dry matter (6.61 %) was observed in escarole cv. 'Indigo'. The differences were statistically significant for both factor A and factor B.

Analyzing the contributions of the tested factors on the dry matter content, we noted significant effects of escarole cultivars and sowing time on the dry matter content in leaves. In the escarole cultivars, the cultivar's contribution in the study years was 71.9 %. Thus, the study indicated that the dry matter content in the escarole cultivars sown within the third ten days of April varied from 6.81 to 9.05 %; it was 6.61–8.79 % in the cultivars sown within the third ten days of May. In the escarole cultivars, the dry matter content was 4.86–10.78 and 4.76–10.58 %, respectively, and this parameter

depended rather on the cultivar assortment than on the sowing period. C. escarole leaves are an excellent source of phenolic flavonoids such as zeaxanthin and lutein. These potent antioxidants, being concentrated in the retina of the eye, prevent the occurrence and development of age-related macular degeneration. In the experiment, the cultivar choice and cultivation period affected their content. Thus, the highest levels of phenolic compounds were detected in cv. 'Indigo' sown within the first ten days of May (2.4 %) and in cv. 'Red Ball' sown within the first ten days of May (2.6 %) or within the third ten days of May (2.6 %). Hence, the best chemical composition of commercial escarole products was recorded for cvs. 'Indigo' and 'Red Ball' sown within the first and third tenb days of May.

The amount of phenolic compounds depended on the escarole cultivar and sowing time. Studies conducted in the Forest-Steppe of Ukraine confirmed the results obtained in the Southern Steppe of Ukraine and presented in this article. Our results will help vegetable growers to choose the priorities and sowing periods for growing the best escarole cultivars in the South of Ukraine; these will be useful for working out plans on farms of various forms of ownership and management, which grow and sell early greens.

Conclusions. The study showed that the timeframes of escarole sowing affected the emergence of seedlings in the Southern Steppe of Ukraine and, by altering the length of plants' vegetation, significantly changed the yield and quality. The optimal timeframe for outdoor sowing of escarole cvs. 'Vohnyshche' and 'Indigo' was the first ten days of May; in this variant, 32.9 t/ha and 30.3 t/ha were harvested, respectively, or 4.7 t/ha and 2.1 t/ha more than in the control. Cvs. 'Palla Rosa' and 'Vohnyshche' sown within the third ten days of May yielded 28.6 t/ha and 30.5 t/ha, respectively, or 0.4 t/ha and 2.3 t/ha more than in the control. The best chemical composition of marketable escarole products was achieved in cvs. 'Indigo' and 'Red Ball' sown within the first and third ten days of May.

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Annotation

Ulianych O. I., Shevchuk K. M., Ulianych K. F.
Cultivation of salad escariole chicory in conditions of climate change

Purpose*. The research was supposed to establish the optimal sowing date of chicory depending on the variety, and to find out the impact on yield and quality.*

Methodology. *It was used generally accepted research methods. Paying high attention to biometric indexes of plant growth and yield.*

Results. *It was proved that the variety of escariol Vognysche was characterized by the small number of leaves – 26,4–25,6 pcs./plant. Red Ball, Indigo, Palla Rosa and Scherbet varieties showed higher results for sowing in the III decade of May and the number of leaves was 31,2–31.7 pcs./plant. The weight of the plant was higher in the Vognysche, Indigo, and Red Ball varieties for sowing in the I decade of May – 242–296 g. In the III decade of May, the Palla Rosa and Vognysche varieties had a higher mass – 258–275 g. High yields of chicory varieties Vognysche and Indigo were obtained for sowing in the I decade of May – 32,9 and 30,3 t/ha, which exceeded the control by 4,7 and 2,1 t/ha. The best chemical composition of commercial products of chicory escarole was observed in Indigo, Red Ball varieties for sowing in the I and the III decade of May. It has been proven that the optimal sowing date for chicory escarole are the I and III decades of May.*

Conclusions. *The results of the research established that in the Southern Steppe of Ukraine, the optimal period for sowing chicory lettuce escarole in open ground for the Vognishche and Indigo varieties is the I decade of May during which 32.9 and 30.3 t/ha were obtained, and for the Palla Rosa, Vognishche varieties, sowing in the III decade of May – 28.6 and 30.5 t/ha. The best chemical composition of marketable products of chicory lettuce escarole was obtained from Indigo and Red Ball varieties for sowing in the 1 and III decade of May.*

Key words: *chicory lettuce, escarioles, variety, sowing date, number of leaves, productivity.*