Scientific Papers. Series B, Horticulture. Vol. LXIV, No. 2, 2020
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

INFLUENCE OF WEATHER AND MINERAL FERTILIZERS ON GROWTH, FLOWERING AND FLOWER QUALITY OF CHINA ASTER IN THE NORTHEASTERN FOREST-STEPPE OF UKRAINE

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Abstract

This study investigates the influence of weather conditions and rates (3.0 g m^{-2}, 6.0 g m^{-2}, 9.0 g m^{-2}) of complex mineral fertilizer (Nitroamophos - $N_{16}P_{16}K_{16}$) on growth, flowering, plant height, and number and diameter of inflorescences of five China aster (Callistephus chinensis L. Nees) cultivars ('Olenka', 'Leleka', Litnia Nich', 'Tsarivna' and 'Yabluneva') during a three-year (2015-2017) study in the Northeastern Forest-steppe of Ukraine. Differences in plant height, number and diameter of inflorescences of cultivars were influenced by variations in weather conditions of the research area, cultivar characteristics, as well as the rate of mineral fertilizer. The increase in the amount of precipitation during the growing season contributed to the growth of the vegetative mass, but negatively affected the formation of the number of inflorescences. The largest inflorescence diameter was formed in the wet condition of 2016 for most cultivars. Unlike weather conditions, mineral fertilizer had considerable effect on the diameter of inflorescence. The most valuable morphological and decorative features were formed for the application of 6.0 g m^{-2} complex mineral fertilizer. Further increase in rate of fertilizer was not appropriate.

Key words: *Callistephus chinensis, cultivar, flower quality, mineral fertilizer, weather.*

INTRODUCTION

Callistephus chinensis belongs to the family *Asteraceae* (*Compositae*) of the genus callistephus (*Callistephus*). The name of the genus comes from two Greek words, *Kalistos* - “the most beautiful’’ and *Stephus* - “crown”, which refers to inflorescence of the flower and thus reflects the high decorative qualities of the plant. The Callisthephus genus includes only the single species *Callistephus chinensis* (L.) Ness, which has become widespread in the flower garden of Europe and other countries of the world, and also called annual aster since 1728 (Kumar & Chandary, 2018).

The natural range of *Callistephus chinensis* is northeastern China, South of the Far East of Russia, and the northern part of the Korean Peninsula. Until now, in these regions, the species is found on the rocks and clay-stony asphalts of the southern slopes of the mountains. In the wild, the plant is characterized by a fairly large habitus, non-terry inflorescences of blue color, and less decorative (Sowmya & Prasad, 2017). The first cultivars of *C. chinensis* were also unattractive, although Chinese gardens have cultivated for a long time (Chawdhuri et al., 2016).

With the development of modern floral business, *C. chinensis* is among the top three most popular crops, second only to chrysanthemums and marigolds in commercial cultivation (Kumar & Chandary, 2018; Wani et al., 2018; Chawdhuri et al., 2016). It is one of the most widespread seasonal ornamental annual flower plants worldwide, which is easily cultivated in open field, pots and bouquets (Maheta et al., 2016).

Scientists have recently and considerably increased interest in the study of this plant. Most of the works published in the last decade were devoted to investigating the growing and agricultural practices of *C. chinensis* under different conditions (Khanna et al., 2016; Kirar et al., 2014; Levandovska et al., 2017; Kumari et al., 2018). Regarding the growth and development of *C. chinensis*, the level of productivity of various cultivars is very specific to their response to weather and climatic conditions of the particular region of cultivation. Thus, *C. chinensis* cultivars do not always maintain their decorative qualities when the region of cultivation is changed. In addition, under different natural and climatic conditions, the variability of plant morphological features and the level of seed productivity are observed (Levandovska 2015; Levandovska et al., 2017).

Special interest of scientists is also focused on the influence of mineral and organic fertilizers on the morphological parameters of the plant, and as a consequence, its decorative qualities. Most of the results indicate that, the recommended rates of mineral and organic fertilizers increased the plant height, number of leaves and flowers, particularly studies by Munikrishnappa and Chandrashekar (2014). Khanna et al. (2016) also emphasize the use of manure and forest litter to produce high-quality floral products for commercial cultivation of *C. chinensis*. Additionally, the influence of fertilizers on the profusion of flowering and duration of seed maturity have been reported to accelerate seed maturity; and the specificity of action of phosphorus fertilizers and bacterial agents respectively accelerated and delayed flowering (Singh et al., 2017). Also, maximum levels of development of the vegetative and reproductive organs of *C. chinensis* were noted for the application of the recommended rates of Nitrogen and Phosphorus and combinations of NPK + Vermi-compost + Azotobactor + PSB (Maheta et al., 2016; Kirar et al., 2014). Similarly, there was an increase in vegetative growth of *C. chinensis* when micronutrients were applied (Verma et al., 2018).

In spite of these well documented positive effects, global environmental changes suggest that, mankind uses excessive amounts of mineral fertilizers (Kumari et al., 2018; Vijayakumar, 2017), which leads to negative effects on air, water and soil, and particularly soil fertility is disturbed (Barman et al., 2017). Alternatively, it is appropriate to combine mineral and organic fertilizers and apply scientifically-based doses (rates) of fertilizers for each specific plant and soil-climatic conditions (Bose et al., 2018; Sharma et al., 2017).

The present study therefore investigates the influence of different rates of mineral fertilizers (Nitroamophos - $N_{16}P_{16}K_{16}$) on growth, flowering and morphometric parameters of *C. chinensis* under the climatic conditions of the Northeastern Forest-steppe of Ukraine. For this region, such studies are very relevant and of great importance for the effective breeding of cultivars, gene pool creation and the expansion of the range of *C. chinensis* in modern landscaping.

MATERIALS AND METHODS

The research was carried out in accordance with the methodological recommendations of Dospekhov (1985). The three-year (2015-2017) research was conducted at the Educational Research and Production Center of Sumy National Agrarian University (ERPC SNAU) in the Northeastern Forest-steppe of Ukraine (N 50° 52.9; E 34° 46.2), to ascertain the effect of three different rates (3.0 g m^{-2}, 6.0 g m^{-2}, 9.0 g m^{-2}) of mineral fertilizers (Nitroamophos – $N_{16}P_{16}K_{16}$) on a set of qualitative and quantitative characteristics of the vegetative and reproductive organs of five cultivars of *C. chinensis* ('Olenka', 'Leleka', Litnia Nich', 'Tsarivna' and 'Yabluneva'). The chernozem soil of the experimental site is coarse-medium on loess loam. The arable layer has a humus content of 4.0%, nitrogen nitrate – 2.2-3.3 mg, ammonia nitrogen – 10.6-11.2 mg, mobile phosphorus forms – 137-158 mg, exchangeable potassium – 35-70 mg g^{-1} of soil. The reaction of the soil solution is close to neutral (pH 6.0).

The influence of various rates of mineral fertilizers on the growth and flowering of *C. chinensis* was studied in small-field experiments and the placement of plots was randomized. Seedlings were grown in a controlled environment of the greenhouse of the ERPC SNAU. Sowing of seeds in boxes was undertaken in the third decade of March of the studied years (2015, 2016, and 2017) respectively, on March 21, 25 and 24. In open soil, seedlings were transplanted in rows manually on areas of 3 m^2 with three replications on May 28 (2015, 2017), and May 25 (2016). Fertilizers were applied directly during the planting process in a row. Plots with no fertilizer served as control. All cultural practices including pest and disease control were performed.

Phenological observations were conducted throughout the vegetation period of plants. The phenological phases were established according to the method described by Beideman (1974) and the methods of phenological observations in the botanical gardens of the Union of Soviet Socialist Republic Academy of Sciences (USSR AS, 1979). A comparative assessment of the morphological and economic characteristics of *C. chinensis* cultivars was carried out during the flowering period in accordance with the methodology of Bilov (1978). Observations and measurements were based on the following parameters: plant height, number of inflorescence and diameter of inflorescence. Data were subjected to analysis of variance (ANOVA) using the Statistica 8 software and Duncan Multiple Range Test (DMRT) was used to separate the means at 5% level of probability.

RESULTS AND DISCUSSION

An important economic and valuable feature of *C. chinensis* is the beginning and the duration of flowering. Using the conventionality described (Levandovska, 2017) in the grouping of cultivars for the flowering period, the following are distinguished: *early-flowering* (flowering at the end of July, the duration of the period "shoots – the beginning of flowering" is 120-130 days); *intermediate-flowering* (flowering in the first half of August, the duration of the period "shoots – the beginning of flowering" is 131-145 days); and *late-flowering* (flowering in the second half of August and later, the duration of the period "shoots – the beginning of flowering" is 146-160 days). The interphase period from emergence of seedlings (germination) to the onset of seed formation for different cultivars of *C. chinensis* lasts 150-190 days. As stated (Iskrenko et al., 2015), the duration of ontogenesis and the flowering period is a genetically endemic feature that strongly depends on the varietal characteristics and favorable weather conditions during the growing season. The influence of the latter factor (weather) can vary the duration of flowering from 40 to 60 days. Under favorable conditions in the northern regions of Ukraine, the end of flowering can occur only through strong autumn frosts, which lead to the death of plants. For the southern regions, the time limit for flowering is the end of October, after which the plants dry out.

The researched varieties of *C. chinensis* ('Olenka', 'Leleka', 'Litnia Nich', 'Tsarivna' and 'Yabluneva'), according to the State Register of Plant Varieties suitable for distribution in Ukraine (SRPV, 2017), fall into three groups based on the terms of flowering, namely: (1) *Early-flowering*: (a) 'Olenka' (the plant is strong, forms a compact plant height of 28-30 cm and a diameter of 25-30 cm. The early flowering begins at the end of July and lasts until the beginning of September and at the same time blooms 8-10 inflorescences with 15-18 inflorescences in total); (b) 'Yabluneva' (compact, colon-shaped, branched plant with a height of 65-70 cm and a plant diameter of 30-35 cm. Seven (7) branches of the first-order, during mass flowering on the plant, there are 6-9 concurrently exposed inflorescences, and only forms up to 30 pieces. It begins to bloom in late July and bloom until the second half of September); (2) *Intermediate- flowering*: (c) 'Litnia Nich' (a plant with a height of 45 cm, a width of 30 cm, compact, strong, rounded form, and is very branched out). During massive flowering, there are 7-10 inflorescences that are opened simultaneously, 19-25 in total, and the flowering begins in the first decade of August. (3) *Late-flowering*: (d) 'Leleka' (broad-leaved plant, 55-60 cm tall and 50 cm wide, slightly branched, blooming at the end of August and bloom for a month). (e) 'Tsarivna' (plant height 45 cm, width 32 cm, semi-stalks, very strong. Flowering begins at the end of the second decade of August. During mass flowering, 3-4 inflorescences sprout in the plant simultaneously, with total of 6-10 pieces).

To determine the influence of weather conditions on the growth and development of *C. chinensis* cultivars, the main hydrothermal indicators provided by the North-East branch of the Institute of Agriculture of the National Academy of Sciences of Ukraine were analyzed by years of research (Table 1).

Table 1. The sum of active temperatures, amount of precipitation and hydrothermal coefficient for the years of research in the conditions of the ERPC SNAU (2015-2017 years)

Year	The sum of active temperatures (°C)	Amount of precipitation for the period of active temperatures (mm)	Hydrothermal coefficient	Moisture condition
2015	2696.1	279.9	1.04	Normal
2016	2793.0	445.8	1.60	Wet
2017	2491.0	148.0	0.59	Dry
Average long-term	2568.0	294.0	1.21	Normal

The 2015 conditions were characterized by a vegetation period close to normal. Compared to the average perennial rainfall, April was 4.1 mm, which was 35.9 mm less than normal. Respectively, in May and June, rainfall was lesser by 41.2 and 58.3 mm, whiles in July and August by 70.8 and 54.6 mm. The air temperature for all months of the growing season in 2015 exceeded the average annual figures. Specifically, in April and May by 0.4°C and 1.2°C, in June and July by 2.3°C and 1.7°C, and greatest in August by 2.5°C. During the vegetation period (April-August), the amount of active temperatures was 2696.1°C, and the precipitation was 279.9 mm.

The growing season of 2016 was characterized by high temperatures and excessive precipitation over certain months. The rainfall in April, May and August were 58.0 mm, 153.1 mm and 124.8 mm respectively, which were 18.1 mm, 99.1 mm and 67.8 mm higher than the average perennials. In June and July, rainfall fell below the norm by 3.4 mm and 13.8 mm. The air temperature during all the months of the vegetation period exceeded the average annual figures. Particularly, in April and July, the highest was by 3.0°C and in June and August by 2.0°C and 2.3°C, respectively. During the vegetation period (April-August), the amount of active temperatures was 2793.0°C, and the precipitation was 445.8 mm.

Weather conditions for the growing season in 2017 were largely characterized by high temperatures and insufficient rainfall compared with the average long-term data. In April and May the amount of precipitation was 13.4 and 31.4 mm, which were lesser by 26.6 and 22.6 mm. The least precipitation compared to the long-term data fell in June (33.2 mm) and August (15.1 mm), which were below the long-term data by 33.8 and 41.9 mm. In July, precipitation was 77.7 mm, exceeding the long-term figures by 1.7 mm. The air temperature in May was lower than the average long-terml values by 0.6°C. In all other months of the vegetation period, the temperature was higher than the norm, in particular the highest in August by 3.9°C, while in April by 0.3°C and in June and July by 0.8°C. During the growing season (April-August), the amount of active temperatures was 2491.0°C, and the precipitation was 148.0 mm.

Thus, the analysis of weather conditions, in particular the hydrothermal coefficient (HTC) as described (Selyaninov, 1937) revealed that the vegetative period of 2015 was normal (HTC = 1.04), 2016 was wet (HTC = 1.60) and 2017 was dry (HTC = 0.59). HTC were computed by the formula: $HTC = \Sigma p \times 10 / \Sigma t$, where Σp is the amount of precipitation or rainfall (mm), for a period with an average daily air temperature above 10°C; Σt is the sum of temperatures (°C), for the period with average daily air temperature beyond 10°C.

Over the years, the cultivars studied passed all stages of ontogenesis and formed seeds. The beginning of the flowering of most cultivars occurred at the end of July to the first half of August. The duration from “shoots - the beginning of flowering” varied between 120-145 days. The results on the phenology of the cultivars allowed establishing certain differences in the varietal characteristics given in the State Register of Plant Varieties suitable for distribution in Ukraine (SRPV, 2017) and the obtained three-year data shown (Table 2).

Table 2. The duration of “shoots - the beginning of flowering” and “flowering” of cultivars of *C. chinensis* (2015-2017)

Phenophase	Cultivar														
	Olenka			Yabluneva			Litnia Nich			Leleka			Tsarivna		
Year	2015	2016	2017	2015	2016	2017	2015	2016	2017	2015	2016	2017	2015	2016	2017
Appearance of shoots	25.03	29.03	30.03	25.03	29.03	30.03	25.03	29.03	30.03	25.03	29.03	30.03	25.03	29.03	30.03
Beginning of flowering	30.07	26.07	03.08	12.08	02.08	09.08	29.07	09.08	12.08	04.08	09.08	11.08	16.08	05.08	11.08
Duration of interphase (days)	128	120	127	141	127	133	127	134	138	133	134	138	145	130	137
Duration of flowering (days)	41	49	37	30	41	37	52	39	41	55	42	41	39	44	40

Thus, according to the observations among the studied cultivars, only one cultivar ('Olenka'), which had the average period for the three years from the “shoots – the beginning of flowering” occurring within 125 days can be classified under the group of early-flowering in the conditions of the ERPC SNAU. The other cultivars have shown to be of intermediate-flowering with the duration from the “shoots – the beginning of flowering” ranging between 133-137 days. Suprisingly, the 'Yabluneva' cultivar which was declared early-flowering, began to flower on average 10 days later than the norm. Also, in contrast, the late group cultivars 'Leleka' and 'Tsarivna' reduced the onset of flowering by 18 and 16 days, respectively.

Assessing the influence of weather conditions of the year on the beginning and duration of flowering, it is revealed that, for most of the studied cultivars, the conditions of 2016, defined as wet, was the best. However, for the ‘Litnia Nich’ and 'Leleka' cultivars, optimum conditions were in 2015 which had a normal moisture condition. Under arid (dry) conditions in 2017, all cultivars began flowering late and had a shorter flowering period as a whole.

The use of fertilizers in the process of cultivating decorative (ornamental) plants allows for highly decorative plants with abundant number of flowers and inflorescences, a bright coloration of flowers and leaves, as well as more pronounced varietal signs. Therefore, a very important step in the cultivation of flower crops, both in closed and open soil is the rational use of fertilizers, which depends on the environment and biological characteristics of plants (Maheta et al., 2016).

The issue of applying fertilizers to ornamental herbaceous plants in the open field has been worked out rather weakly. In literature, contradictory data on the mineral nutrition of individual annual and perennial flower crops are presented or there are no such recommendations at all.

Based on the current growth in demand for aesthetic annual flowering plants, for both private and public landscaping, determining the optimal rate of fertilizer and the method of its application is an urgent necessity. During the three growing seasons, the influence of different application rates of complex mineral fertilizers on the main economic and valuable features of *C. chinensis* was investigated. Since for iliac plants, the determining factor for decoration is the duration and abundance of flowering, these parameters were subjected to analysis. Duration of flowering of plants according to cultivars for different rates of mineral fertilizers is presented (Table 3).

Table 3. Beginning and duration of the phenophase (flowering) of *Callistephus chinensis* cultivars (2015-2017)

Rates of fertilizer	Phase and date of flowering									Duration of flowering (days)			
	Beginning			Massive			End						
	2015	2016	2017	2015	2016	2017	2015	2016	2017	2015	2016	2017	Average
Early-flowering													
'Olenka'													
Control	30.07	26.07	3.08	6.08	29.07	8.08	10.09	13.09	10.09	41	49	37	42.3
3.0 g m^{-2}	30.07	26.07	1.08	5.08	29.07	5.08	10.09	13.09	10.09	41	49	39	43
6.0 g m^{-2}	30.07	25.07	30.07	5.08	28.07	3.08	10.09	13.09	10.09	41	50	41	44
9.0 g m^{-2}	30.07	25.07	1.08	5.08	28.07	5.08	10.09	13.09	10.09	41	50	39	43.3
'Yabluneva'													
Control	12.08	9.08	9.08	14.08	11.08	13.08	12.09	19.09	16.09	30	41	37	36
3.0 g m^{-2}	10.08	5.08	7.08	12.08	8.08	10.08	12.09	18.09	16.09	32	44	39	38.3
6.0 g m^{-2}	8.08	4.08	9.08	10.08	7.08	13.08	12.09	17.09	16.09	34	44	37	38.3
9.0 g m^{-2}	3.08	4.08	7.08	7.08	7.08	10.08	12.09	17.09	16.09	39	44	39	40.7
Intermediate-flowering													
'Litnia Nich'													
Control	29.07	9.08	12.08	5.08	10.08	16.08	19.09	17.09	23.09	52	39	41	44
3.0 g m^{-2}	29.07	2.08	12.08	5.08	5.08	16.08	19.09	16.09	23.09	52	45	41	46
6.0 g m^{-2}	29.07	1.08	11.08	5.08	4.08	15.08	19.09	15.09	23.09	52	45	42	46.3
9.0 g m^{-2}	29.07	1.08	11.08	5.08	4.08	15.08	19.09	15.09	23.09	52	45	42	46.3
Late-flowering													
'Leleka'													
Control	4.08	9.08	11.08	5.08	12.08	15.08	22.09	19.09	15.09	49	42	34	41.7
3.0 g m^{-2}	4.08	8.08	10.08	5.08	11.08	14.08	22.09	18.09	15.09	49	41	35	41.7
6.0 g m^{-2}	29.07	5.08	2.08	5.08	8.08	5.08	22.09	16.09	15.09	55	42	43	46.7
9.0 g m^{-2}	29.07	5.08	4.08	5.08	8.08	7.08	22.09	16.09	15.09	55	42	41	46
'Tsarivna'													
Control	16.08	5.08	11.08	23.08	9.08	15.08	25.09	18.09	21.09	39	44	40	41
3.0 g m^{-2}	18.08	4.08	11.08	21.08	7.08	15.08	25.09	18.09	21.09	37	45	40	40.7
6.0 g m^{-2}	6.08	4.08	10.08	13.08	7.08	14.08	25.09	17.09	21.09	49	44	41	44.7
9.0 g m^{-2}	13.08	4.08	10.08	15.08	7.08	14.08	25.09	17.09	21.09	42	44	41	42.3

The abundance of flowering depends on the biological characteristics of the cultivar, and its duration may vary depending on the soil-climatic conditions of cultivation. Also, optimal conditions for light, heat, and moisture in certain periods of plant development can help accelerate the flowering of *C. chinensis* for 5-10 days (Masaye & Rangwala, 2009;

Munikrishnappa & Chandrashekar, 2014). Thus, the analysis of the average flowering time for 2015-2017 indicated that, the minimum index (36 days) occurred in the control of 'Yabluneva' and the maximum (46.7 days) in the 'Leleka' cultivar for the application of 6 g m^{-2} mineral fertilizer. There was no significant dependence for the duration of flowering on the different rates of mineral fertilizer. However, it is proved that the duration of flowering depends on the characteristics of the cultivar and weather conditions of the year.

The plant height, according to literature, depends largely on the biological characteristics of the cultivar and is stable. It provides the strength of the plant and is one of the most important indicators that determine the general characteristics of habitus. For flowering plants, the size and shape of the plant is quite important, since it regulates the direction of its use. With the use of *C. chinensis* as a flower border, where the height variation is unacceptable, the positive response of plant height to mineral fertilizers is negative. At the same time, when cultivating varieties by cut, increasing the height increases their commercial grade.

The height of *C. chinensis* plants for application of various rates of mineral fertilizers varied within the options (Table 4). According to the description of cultivars, the samples can be divided into three groups: short (plant height 20-30 cm), medium (plant height 30-50 cm) and tall (plant height above 50 cm). Also, according to the general morphological characteristics, the 'Olenka' cultivar is short; the cultivars 'Tsarivna' and 'Litnia Nich' belong to the medium-height group, while 'Leleka' and 'Yabluneva' are very tall. However, comparing the values of measurements made in the present study at the experimental sites of the ERPC SNAU and the results of tests of the originators of the cultivars, there was a considerable decrease in plant height of the cultivars 'Leleka', 'Litnia Nich', 'Tsarivna' and 'Yabluneva' except for the early-flowering 'Olenka' cultivar.

The application of mineral fertilizers during the cultivation of *C. chinensis* had a positive effect on plant height (Table 4). The average plant height for the application of the three rates of fertilizer on 'Olenka' cultivar exceeded the control by 2-8.7%. The rest were as follows: 'Leleka' (2.4-5.6%); 'Litnia Nich' (5.0-12.7%); 'Tsarivna' (10.5-15.9%); 'Yabluneva' (8-13.9%). There was a significantly ($P<0.05$) taller plant for all five cultivars for the application of 6 g m^{-2} or 9 g m^{-2} fertilizer compared with control. For all cultivars, when compared with the maximum rate of fertilizer (9 g m^{-2}), application of 6 g m^{-2} fertilizer resulted in taller plants and the difference was as well significant for two cultivars ('Olenka' and 'Yabluneva'). Additionally, application of the minimum rate of fertilizer (3 g m^{-2}) generated significantly ($P<0.05$) taller plants in only two cultivars ('Yabluneva' and 'Tsarivna') compared to their controls.

The analysis of the influence of weather conditions on plant height showed that, the year 2017 was the most favorable for the formation of tall plants for all cultivars of *C. chinensis*, except 'Tsarivna' (Table 4). The climatic conditions of 2016 negatively affected the height of the cultivars 'Leleka' and 'Litnia Nich'. At the same time, 'Olenka' and 'Yabluneva' cultivars had a stable value for this morphoparameter for the three years. Thus, it can be concluded that, plant height was affected by the cultivar, weather conditions and mineral fertilizer.

It is important to note that, the application of mineral fertilizers during the cultivation of the cultivars 'Leleka', 'Litnia Nich', 'Tsarivna' and 'Yabluneva' did not affect the formation of sufficiently tall plants with characteristic values for these cultivars. Thus, the given cultivars for specific soil-climatic conditions tend to reduce the size, particularly, the heights and diameter of the plant, regardless of the weather conditions of the year of cultivation and supply of nutrients.

Table 4. Influence of rates of mineral fertilizers on plant height of *C. chinensis* (2015-2017)

Rates of fertilizer	Plant height (cm)			
	2015	2016	2017	Average*
′Olenka′				
Control	25.3	24.5	26.2	25.3 c
3.0 g m^{-2}	25.8	25.3	26.2	25.8 c
6.0 g m^{-2}	27.3	27.4	27.7	27.5 a
9.0 g m^{-2}	26.8	26.8	26.6	26.7 b
′Leleka′				
Control	35.7	36.3	40.4	37.5 a
3.0 g m^{-2}	39.1	35.1	41.0	38.4 a
6.0 g m^{-2}	40.1	37.4	41.4	39.6 a
9.0 g m^{-2}	39.9	36.8	41.3	39.3 a
′Litnia Nich′				
Control	37.4	36.3	35.3	36.3 c
3.0 g m^{-2}	40.9	36.5	36.8	38.1 bc
6.0 g m^{-2}	41.7	39.4	41.5	40.9 a
9.0 g m^{-2}	41.0	37.6	41.4	40.0 ab
′Tsarivna′				
Control	26.6	28.9	27.3	27.6 b
3.0 g m^{-2}	32.0	31.4	28.1	30.5 a
6.0 g m^{-2}	34.8	32.3	28.8	32.0 a
9.0 g m^{-2}	32.1	31.4	28.7	30.7 a
′Yabluneva′				
Control	36.5	38.7	37.4	37.5 c
3.0 g m^{-2}	40.2	41.3	39.9	40.5 b
6.0 g m^{-2}	42.2	42.9	42.9	42.7 a
9.0 g m^{-2}	41.9	41.7	40.6	41.4 b

*In each column for each cultivar, means with same letter (s) are not significantly different at $P<0.05$

Table 5. Influence of different rates of mineral fertilizers on the number and diameter of inflorescences of *Callistephus chinensis* ('Olenka', 'Leleka' and 'Litnia Nich' cultivars)

Rates of fertilizer	Number of inflorescences (pcs.)				Diameter of inflorescences (cm)			
	2015	2016	2017	Average	2015	2016	2017	Average*
'Olenka'								
Control	3.7	3.1	5.2	4.0 a	6.0	5.9	6.2	6.0 c
3.0 g m^{-2}	5.0	4.8	5.8	5.2 a	6.8	7.0	6.5	6.8 b
6.0 g m^{-2}	5.7	5.0	6.4	5.7 a	7.0	7.3	6.9	7.1 a
9.0 g m^{-2}	5.3	4.6	6.3	5.4 a	7.0	7.1	6.8	7.0 ab
'Leleka'								
Control	9.6	5.0	9.5	8.0 a	7.8	7.6	8.7	8.0 b
3.0 g m^{-2}	13.0	5.4	10.9	9.8 a	8.0	7.9	8.7	8.2 ab
6.0 g m^{-2}	14.0	6.6	13.0	11.2 a	8.5	8.7	8.9	8.7 a
9.0 g m^{-2}	13.3	5.7	11.3	10.1 a	8.2	8.2	8.8	8.4 ab
'Litnia Nich'								
Control	9.0	6.3	10.4	8.6 a	6.0	6.5	5.8	6.1 c
3.0 g m^{-2}	9.3	7.6	11.2	9.4 a	6.5	6.8	5.9	6.4 bc
6.0 g m^{-2}	10.3	8.2	15.3	11.3 a	7.0	7.5	6.5	7.0 a
9.0 g m^{-2}	10.3	8.0	12.9	10.4 a	6.8	7.3	6.5	6.9 ab

*In each column for each cultivar, means with same letter (s) are not significantly different at $P<0.05$

One of the most important indices of ornamental plants is the number and diameter of inflorescences (Levandovska, 2015). They are important because they determine the level of decoration and affect performance. The effect of different rates of mineral fertilizers on number and diameter of inflorescences of *C. chinensis* cultivars are given in Table 5 and Table 6.

The average number of inflorescences formed on plants of the 'Olenka' cultivar in the three variants exceeded the control by 30 to 42.5%. The others were as follows: 'Leleka' (22.5-40%); "Litnia Nich" (9.3-31.4%); 'Tsarivna' (16.3-48.8%); 'Yabluneva' (15.4-40.4%). Hence, the application of mineral fertilizers positively influenced the number of inflorescences for all *C. chinensis* cultivars.

However, among the treatments, application of 6 g m^{-2} fertilizer generated the highest number of inflorescences in all cultivars, but compared to control, it was only significantly ($P<0.05$) higher for just two cultivars ('Tsarivna' and 'Yabluneva').

Table 6. Influence of different rates of mineral fertilizers on the number and diameter of inflorescences of *Callistephus chinensis* ('Tsarivna' and 'Yabluneva' cultivars)

Rates of fertilizer	Number of inflorescences (pcs.)				Diameter of inflorescences (cm)			
	2015	2016	2017	Average	2015	2016	2017	Average
'Tsarivna'								
Control	5.0	3.6	4.2	4.3 b	9.0	9.3	9.0	9.1 b
3.0 g m^{-2}	6.0	3.7	5.3	5.0 ab	9.0	9.4	9.3	9.2 b
6.0 g m^{-2}	8.0	4.9	6.3	6.4 a	9.5	10.1	9.9	9.8 a
9.0 g m^{-2}	6.6	3.9	5.9	5.5 ab	9.2	9.8	9.7	9.6 a
'Yabluneva'								
Control	5.3	4.2	6.1	5.2 b	7.9	7.6	8.1	7.9 b
3.0 g m^{-2}	6.0	5.1	6.8	6.0 ab	8.0	7.9	8.7	8.2 b
6.0 g m^{-2}	9.0	6.0	6.9	7.3 a	8.7	8.5	9.2	8.8 a
9.0 g m^{-2}	8.5	5.3	6.5	6.8 ab	8.5	7.9	8.8	8.4 ab

*In each column for each cultivar, means with same letter (s) are not significantly different at $P<0.05$

Weather conditions of vegetation had an impact on the number of inflorescences. The wet conditions of the year 2016 proved to be the least favorable for the implementation of the reproductive potential of all studied cultivars (Table 5; Table 6). For the cultivars 'Leleka', 'Tsarivna' and 'Yabluneva', the greatest number of inflorescences was formed in 2015 (normal moisture conditions), whiles for 'Olenka' and 'Litnia Nich', it was in 2017 (dry). According to the research findings, there was a certain correlation between the weather conditions of the year and the number of inflorescences. So, the increase in the amount of precipitation during the growing season contributes to the development of the vegetative mass, but also negatively affects the formation of the number of inflorescences in *C. chinensis*. For most cultivars, the optimal conditions for the development of the reproductive phase occurred in the year (2015) that had normal conditions for moisture, but for the 'Litnia Nich' cultivar, it was the dry condition of the year 2017.

The inflorescence diameter like other indicators, tended to increase for the application of different rates of mineral fertilizers in all studied cultivars (Table 5; Table 6). For the 'Olenka' cultivar, the increase in the average diameter of inflorescences due to fertilizing was 13.3-18.3% compared to control. The others were as follows: 'Leleka' (2.5-8.8%); 'Litnia Nich' (4.9-14.8%); 'Tsarivna' (1.1-7.7%); 'Yabluneva' (3.8-11.4%). Consequently, the diameter of inflorescence responded positively to the application of mineral fertilizers. Nonetheless, for all treatments, application of 6 g m^{-2} fertilizer resulted in a significantly ($P<0.05$) larger average diameter of inflorescences except for the maximum fertilizer applications (9 g m^{-2}) and also application of 3 g m^{-2} fertilizer for the 'Leleka' cultivar.

Based on the weather conditions of the research years, variations in the diameter of inflorescence for the five cultivars are shown (Table 5; Table 6). It was established that the largest average inflorescence diameter were formed in 2016 for three cultivars 'Olenka' (6.8 cm), 'Litnia Nich' (7.0 cm) and 'Tsarivna' (9.7 cm), and in 2017 for 'Leleka' (8.8 cm) and 'Yabluneva' (8.7 cm). For most cultivars in 2015, the average diameters of inflorescences were average, with values ranging between that of the other research years (2016 and 2017), except for 'Tsarivna' which recorded the least (9.2 cm). Unlike mineral fertilizer, weather condition did not have a considerable effect on the diameter of inflorescence.

CONCLUSIONS

During the growing season, differences in plant height, number and diameter of inflorescences of *C. chinensis* cultivars ('Olenka', 'Leleka', 'Litnia Nich', 'Tsarivna' and 'Yabluneva') were influenced by variations in the weather conditions of the research area, cultivar characteristics, as well as the rate of mineral fertilizer. The largest increase in height when fertilizing, compared to control was observed in the cultivar 'Tsarivna' (15.9%), while the smallest was in ‘Olenka’ (2.0%). It was established that, increases in the amount of precipitation during the growing season contributes to the growth of the vegetative mass, but negatively affects the formation of the number of inflorescences of *C. chinensis*. For most cultivars, the optimal conditions for the growth of the reproductive phase occurred in the year (2015) that had normal moisture, but dry condition (2017) for the 'Litnia Nich' cultivar. The largest inflorescence diameter was formed in the wet condition of the year 2016 for most cultivars ('Olenka', 'Litnia Nich' and 'Tsarivna') and in 2017 for 'Leleka' and 'Yabluneva'. Largely, cultivars in 2015 had average inflorescence diameter. Unlike weather conditions, mineral fertilizer had considerable effect on the diameter of inflorescence. Thus, in comparison with control, the inflorescence diameter was the largest for the cultivar 'Olenka' (18.3%) and the least for 'Tsarivna' (1.1%). The most valuable morphological and decorative features were formed for the application of 6.0 g m^{-2} complex mineral fertilizer (Nitroamophos – $N_{16}P_{16}K_{16}$). Further increase in rate of fertilizer was not appropriate.

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