SECTION OF BIOLOGY AND ENVIRONMENTAL SCIENCES

COMPREHENSIVE ASSESSMENT OF THE SUCCESS OF THE INTRODUCTION OF *CHRYSANTHEMUM MORIFOLIUM* (RAMAT.) HEMSL

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Abstract
The results of a comprehensive assessment of the success of the introduction of *Chrysanthemum morifolium* (Ramat.) Hemsl. plants in the conditions of the National Dendrological Park “Sofiyivka” of the National Academy of Sciences of Ukraine are presented. We have supplemented the methodology for assessing the success of the introduction of herbaceous plants by M. O. Smolinska with such indicators as resistance to wetting in winter and spring, drought resistance, decorativeness and numerical reflections of the level of adaptation of *Ch. morifolium* plants. The vast majority of the studied *Ch. morifolium* varieties have an average level of adaptation and belong to the II group of prospects with a score of 32 to 39. The varieties 'Gusi lebedi', 'Snezhnii shar', 'Kryzhynka', 'Slovyanochka', 'Maskulino Oranj', 'Venus Galati' have a high level of adaptation and belong to the I group of prospects, with the sum of points from 41 to 44.
Keywords: variety, level of adaptation, introduction, indicators.

Introduction

Chrysanthemum morifolium (Ramat.) Hemsl. is a popular autumn-flowering plant all over the world [2] and is considered the second most valuable flowering plant after the rose [17]. This scientific name combines all garden forms of chrysanthemum. Modern varieties *Ch. morifolium* were formed as a result of multiple cycles of complex interspecific crossing. This process lasted over 2500 years and has an interesting history [7]. So, chrysanthemums were cultivated in China 3000 years ago, and in Europe from the middle of the 17th century [2]. For example, chrysanthemums were cultivated in China 3000 years ago, and in Europe since the mid-17th century [2]. There are two opinions: one is that the chrysanthemum originated from a single species, the other is that two different chrysanthemums, *Ch. indicum* and *Ch. morifolium*, were the mother forms of Chinese and Western cultivars [18]. All modern cultivars are the result of long-term hybridisation, spontaneous and introduced mutations, and selection [2]. There are more than 20,000 varieties in the world, about 7,000 in China [19], more than 15,000 in Japan, and more than 6,000 in the UK [2]. But these numbers are not stable, they are constantly changing. After all, some varieties disappear and new ones are created.

The variety is not stable and can change significantly when moving to other geographical and ecological conditions [9]. Varietal studies of domestic and foreign selection were carried out by researchers of the National Botanical Garden named after M. M. Hryshko of the National Academy of Sciences [12], the Kryvyi Rih Botanical Garden of the National Academy of Sciences [6], the Dnipro National University named after Oles Honchar [1] and other institutions, as well as amateurs. As a result, collections of *Ch. morifolium* plants have been created in many botanical gardens of Ukraine and private collections. These collections are the source of replenishment of our collection. Thus, at present, the collection of *Ch. morifolium* (synonym *Chrysanthemum hortorum* W. Mill. [23] includes 75 varieties in the National Dendrological Park "Sofiyivka" of the National Academy of Sciences of Ukraine. The quantitative composition of the collection of chrysanthemum varieties of hybrid origin is dynamic, as some varieties are lost as a result of a narrow ecological amplitude, and others are replenished in order to find varieties resistant to climatic conditions. After all, the success of the introduction is determined by the adaptive capacity of plants, which is manifested in the successful passage of all stages of individual and seasonal development of plants *ex situ*. Ignorance of the biological characteristics of the variety, its requirements to environmental factors of the introduction region causes deterioration of morphological traits of *Ch. morifolium* plants.

A comprehensive assessment of the success of the introduction is the next stage of the introduction work, which is based on generalised knowledge about the ecological and biological characteristics of plants under the conditions of introduction. Therefore, the aim of our research is a comprehensive assessment of the success of the introduction of *Ch. morifolium* plants in the conditions of the National Dendrological Park "Sofiyivka" of the National Academy of Sciences of Ukraine.

Material and Methods

The objects of our research were plants of *Ch. morifolium* varieties cultivated in the collection area of

the Sofiyivka Dendrological Park for the last eight years: 'Opal', 'Pryntsesa Diana', 'Linda', 'Molfretta Pink', 'Nova era', ' Zefir', ' Olyna ', 'Daphne White', 'Okura Red', 'Axima White', 'Diuimovochka', 'Maskulino Oranj', 'Perlynka', 'Venus Galati', 'Ceus', 'Belgo Lilak', 'Ida', 'Tricky White', 'Ulibka oseni', 'Kryzhynka', 'Slovyanochka', 'Snezhnii shar', 'Gusi lebedi', 'Molfretta Orang', 'Padre Lilac'.

The dendrological park is located on the north-eastern outskirts of the city of Uman, Cherkasy region. Its geographical location is determined by 48º46' north latitude and 30º14' east longitude from Greenwich [13]. The city of Uman, according to the botanical and geographical zoning of Ukraine, is located in the central part of the Right-Bank Forest-Steppe of Ukraine, and according to the physical and geographical zoning it belongs to the Western Ukrainian Forest-Steppe Province [16]. The climate of the zone where the experiments were conducted is characterised as temperate continental, with an average annual air temperature of +7.3...+9.4 ºC. According to agrometeorological observations in the zone, the climate is characterised by the following features:

— moderately cold winters with a significant amplitude of air temperature fluctuations on some days, with little precipitation, little snow cover, and sometimes strong easterly winds;

— a moderately warm spring with a significant drop in air temperature on some days, cold, sometimes dry winds and uneven distribution of precipitation;

— moderately hot summers, in some years with a dry growing season and uneven distribution of precipitation, often in the form of showers, with a predominance of westerly winds;

— moderately warm autumn, sometimes with significant temperature fluctuations at the end of the period [14].

The meteorological indicators of the study area are given according to the data of the Uman meteorological station of the Cherkasy Regional Centre for Hydrometeorology (Tables 1, 2).

Table 1

Amount of precipitation, mm

Year	Month											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
2016	74,0	60,0	27,0	32,0	114,0	74,0	16,0	28,0	7,0	87,0	49,0	33,0
2017	22,0	39,0	26,0	53,0	46,0	41,0	59,0	30,0	39,0	54,0	38,0	102,0
2018	58,0	44,0	66,0	18,0	18,0	82,0	93,0	3,0	105,0	13,8	49,9	50,5
2019	55,1	23,8	16,3	22,4	35,6	69,8	33,8	19,2	30,6	10,3	14,0	45,7
2020	12,7	50,5	23,9	21,0	101,0	70,4	21,4	17,1	27,4	81,5	19,4	32,6
2021	59,7	43,2	32,4	49,9	56,4	105,0	89,9	69,9	16,2	7,0	21,2	91,2
2022	23,9	7,2	13,4	57,7	22,4	36,3	28,1	44,4	99,2	10,0	71,8	13,9
2023	6,0	20,5	27,2	129,6	42,4	15,8	92,5	12,4	7,2	33,5	62,3	55,5

Table 2

Average air temperature, ºC

Year	Month											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
2016	-5,6	2,5	4,5	12,3	14,7	20	21,6	20,7	15,7	6,5	1,7	-1,9
2017	-5,2	-2,8	5,9	9,7	14,8	20	20,6	22,1	16,5	8,7	3,4	-0,8
2018	-3,0	-3,6	-1,5	13,5	17,9	20,2	20,7	22,1	15,8	10,1	0,2	-2,0
2019	-4,7	0,5	4,5	9,6	17,0	22,4	20,0	20,7	15,6	8,2	5,5	2,1
2020	0,4	4,5	6,3	9,2	12,5	20,9	21,7	20,9	17,8	8,2	5,5	2,1
2021	-2,3	-7,3	2,0	7,4	14,0	19,8	23,2	20,3	13,0	12,7	3,7	0,0
2022	-1,3	4,6	2,0	8,6	14,5	20,5	21,0	21,8	13,1	7,2	4,7	-1,0
2023	0,2	3,7	5,1	8,8	15,4	19,6	21,29	22,9	18,9	10,0	3,7	-0,4

Climatograms, comparing the annual course of air temperatures with the course of precipitation, are compiled according to the Walter-Gossen method [10], in which 10ºC corresponds to 20 mm of precipitation on the ordinate axis.

Diseases and their pathogens on the studied plants are given according to the results of laboratory studies in 2019 by Agroanalyz LLC.

The success of plant introduction was assessed according to the 5-point scale of M. O. Smolinska according to seven main indicators: growth of monocarpic shoot (1 point — depressed; 2 — weak, slow; 3 — average, satisfactory; 4 — normal; 5 — intensive), flowering (1 point — periodic, weak; 2 — periodically good; 3 — less than 25% of plants bloom annually; 4 — up to 50% of plants bloom annually; 5 — massive annually), fruiting (1 point — absent; 2 — periodically, seeds are dissimilar; 3 — periodically, seeds are similar; 4 — regular, single or no self-seeding; 5 — regular, mass self-seeding), vegetative reproduction (1 point — absent; 2 — weak, vegetative rudiments 1-2; 3 — average, vegetative rudiments 3-4; 4 — good, vegetative rudiments 4-5; 5 — intensive, vegetative rudiments more than 5), resistance to diseases and pests (1 point — up to 50% of plants are affected annually; 2 — up to 50% of plants are affected periodically; 3 — less than 25% of plants are affected periodically; 4 — single damage, periodically; 5 — not affected), frost resistance (1 point — more than 50% of plants freeze out annually; 2 — 25% of plants freeze out annually; 3 — less than 25% of plants freeze out periodically; 4 — damaged by spring frosts, periodically; 5 — not damaged), viability and self-regeneration (1 point — does not exist for long

and dies after 2-3 years; 2 — the total number of individuals decreases from year to year; 3 — the total number of individuals does not decrease and does not increase; 4 — the total number of individuals increases from year to year ; 5 — displacement of other species, active spread outside the site). The sum of the scores was used to determine the level of adaptation and the group of prospects (I - species is promising, stable in introduction; high level of adaptation (28-35 points); II - species is promising, but not sufficiently stable (weak seed and vegetative reproduction); average level of adaptation (21-27 points); III - species of low prospects, insufficiently stable, no self-renewal; low level of adaptation (14-20 points); IV - species not promising, unstable, falls out after 2-3 years of cultivation; not adapted (7-13 points) [21].

Results.

The general appearance of the studied plants is determined by the size, nature of tillering and branching, the direction of growth of monocarpic shoots, as well as the shape and arrangement of leaves and inflorescences. The cycle of development of monocarpic shoots of *Ch. morifolium* plants is a species characteristic, and monocyclic shoots are the main structural units. The cycle is divided into vegetative and generative phases. The rhythm of shoot development is characterized by the fact that with the onset of the growing season, shoots develop from the renewal buds (vegetative phase) that are in a state of winter dormancy, forming spherical and hemispherical bushes. Buds of restoration are placed on the basal part of the shoots, since the main part of the shoot dies in the winter, or/and on specialized organs of vegetative restoration — rhizomes and on its annual branches (Table 3, Figure 1).



Figure 1. Monocarpic shoots of Ch. morifolium 'Snezhnii shar' plants developing from renewal buds: a. — on the rhizome (1 — on annual offshoots, 2 — directly on the rhizome); b. — basal part of the shoot

Table 3

Location of renewal buds in plants *Ch. morifolium*

№	Name of the variety	Renewal buds		
		on the basal part of the shoot	on the rhizome	on the basal part of the shoot and on the rhizome
1.	'Opal'	+		
2.	'Pryntsesa Diana'	+		
3.	'Linda'	+		
4.	'Molfretta Pink'	+		
5.	'Nova era'	+		
6.	'Zefir'	+		
7.	'Olyna'	+		
8.	'Daphne White'	+		
9.	'Okura Red'	+		
10.	'Axima White'	+		
11.	'Diuimovochka'			+
12.	'Maskulino Oranj'	+		
13.	'Perlynka'	+		
14.	'Venus Galati'	+		
15.	'Ceus'	+		
16.	'Belgo Lilak'	+		
17.	'Ida'	+		
18.	'Tricky White'	+		
19.	'Ulibka oseni'		+	
20.	'Kryzhynka'		+	
21.	'Slovyanochka'			+
22.	'Snezhnii shar'			+
23.	'Gusi lebedi'	+		
24.	'Molfretta Orang'	+		
25.	'Padre Lilac'	+		

Note: + — inherent feature.

The presence of renewal buds ensures the ability of plants to regenerate themselves. Plants with renewal buds located on the basal part of the shoot and on the rhizome have the greatest ability to do so (Table 3), resulting in an increase in the number of individuals of the variety from year to year. However, when characterizing the viability and ability to self-renewal, the number of renewal buds per individual and life expectancy should also be taken into account. The number of awakened renewal buds on the basal part of the shoot can vary from 3 to 6, which in turn affects the total number of plants of a particular variety. With a decrease in the number of renewal buds, the life expectancy of one individual decreases. Thus, the life expectancy of the studied plants is on average up to five years: in the first year of ontogeny, plants acquire varietal morphological and generative characteristics, in the second and third years, plants reach their greatest decorative effect, in the fourth and fifth years, plants gradually become depressed and die.

The success of the introduction also depends on the timing and duration of the phenophases of plants. They are not strictly calendarized [3]. The determining factor in the timing of the beginning of the plant growing season is air temperature. The vegetation of the studied varieties begins mainly in the first decade of March, at an average monthly air temperature of 2 ºC to 6 ºC (Table 2). The growth intensity of monocarpic shoots depends on a combination of factors - genetic characteristics of plants, air temperature and rainfall, which is manifested in the habitus of plants. Among the studied varieties, according to habitual traits, we distinguish the groups of multiflora, undersized, medium-sized, and tall. The multiflora group, with a spherical bush shape and a height of up to 40 cm, includes plants of the varieties 'Linda', 'Molfretta Pink', 'Nova era', 'Zefir', 'Daphne White', 'Axima White', 'Venus Galati', 'Ceus', 'Molfretta Orang', 'Padre Lilac', 'Belgo Lilak', 'Ida', 'Maskulino Oranj', 'Okura Red'; for low-growing plants, with a height of 20-45 cm — 'Diuimovochka', 'Kryzhynka', 'Snezhnii shar', 'Gusi lebedi'; for medium-sized plants, with a height of 45-55 cm — 'Pryntsesa Diana', 'Ulibka oseni', 'Opal', 'Olyna'; for tall plants, with a height of more than 55 cm — 'Perlynka', 'Slovyanochka'. Fluctuations in shoot growth of the studied plants are proportional to fluctuations in weather conditions. Thus, Figures 2, 3, 4, 5, 6 show that in the spring (May) of 2016, an increase in temperature to 15 ºC with precipitation of 114 mm (Table 1) promotes intensive shoot growth and we note peaks in growth. In 2017 (Figure 7, 8, 9, 10, 11), during the same period, a decrease in precipitation to 46 mm and at the same air temperature causes a decrease in the growth of monocarpic shoots. Summer high temperatures (25º C and above) and insufficient moisture suspend the genetically determined cycle of development of the vegetative and generative parts of plants.

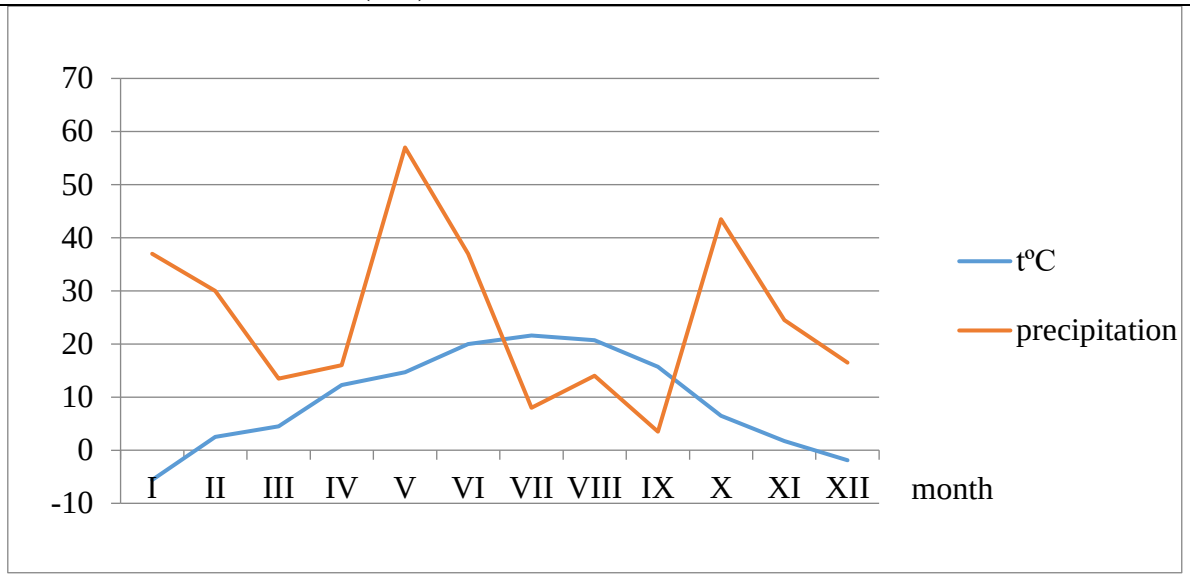


Figure 2. Climatodiagram of the research region in 2016

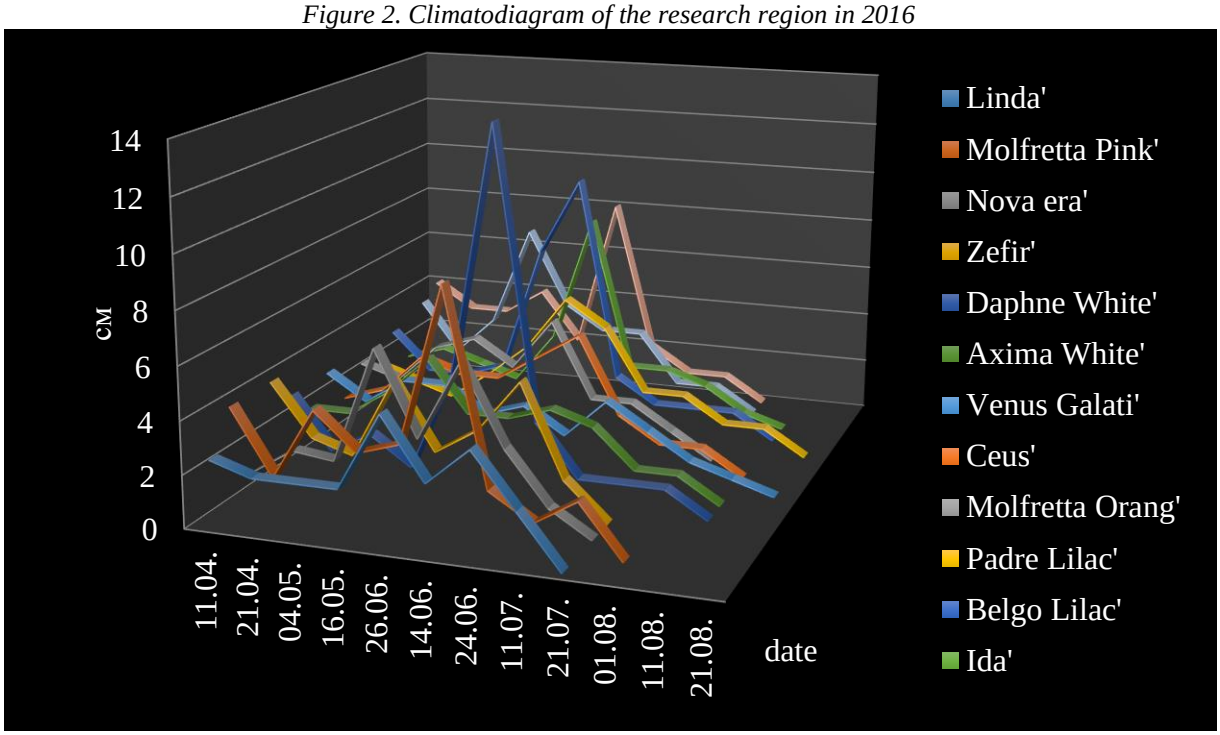


Figure 3. Growth intensity of shoots of Ch. morifolium plants of the multiflora group in 2016

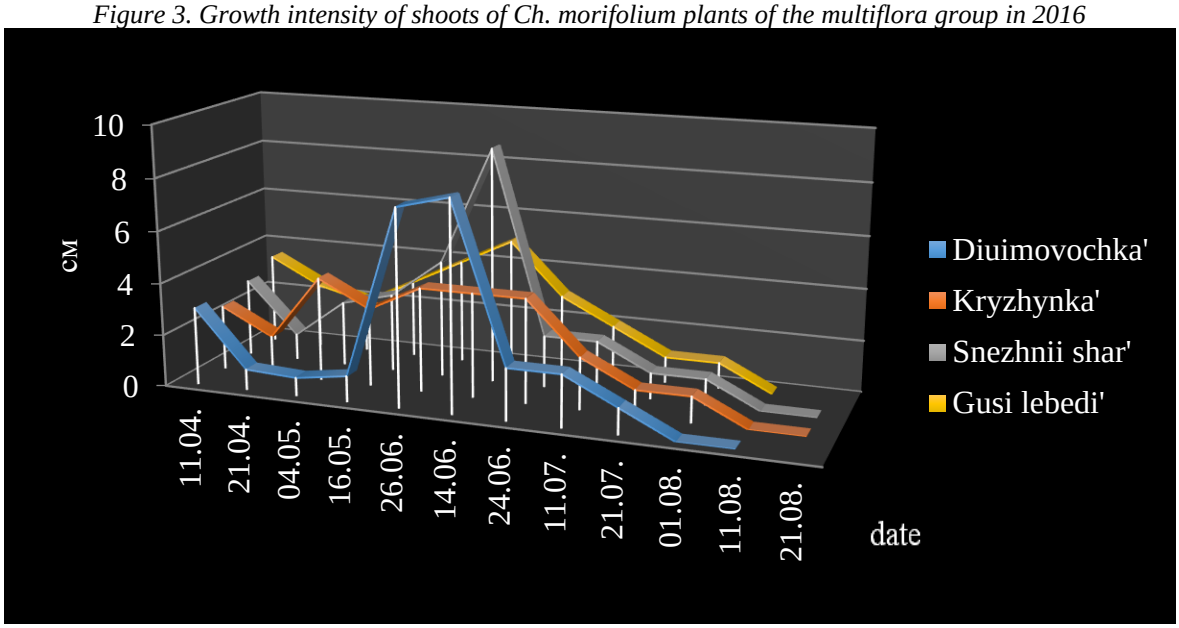


Figure 4. Growth intensity of shoots of Ch. morifolium plants of the stunted group in 2016

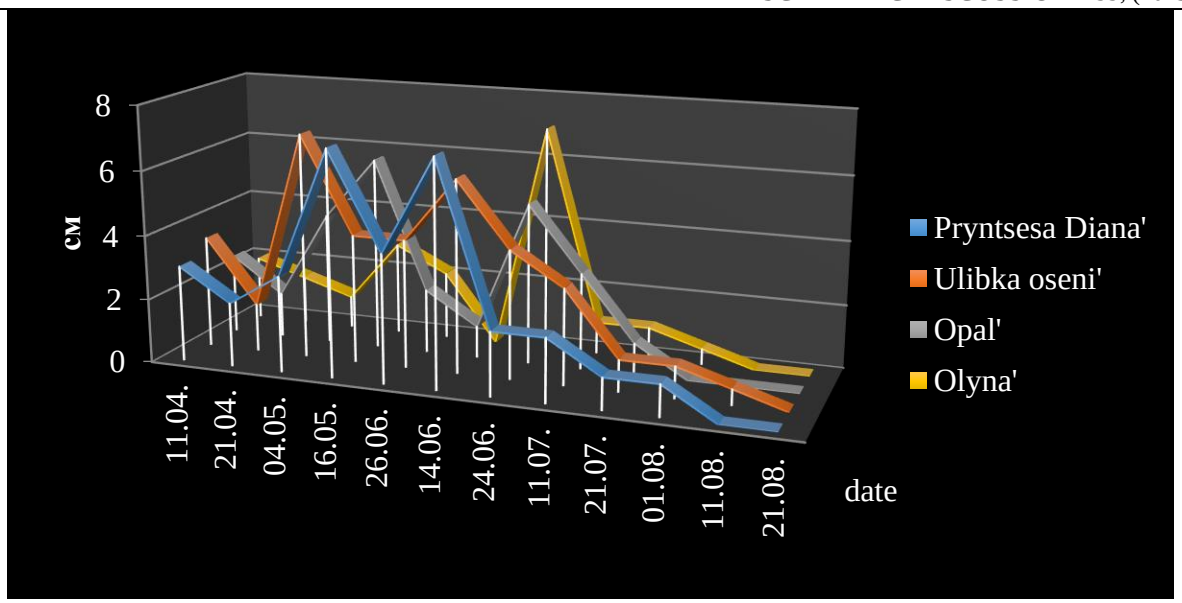


Figure 5. Growth intensity of shoots of Ch. morifolium plants of medium-sized group in 2016

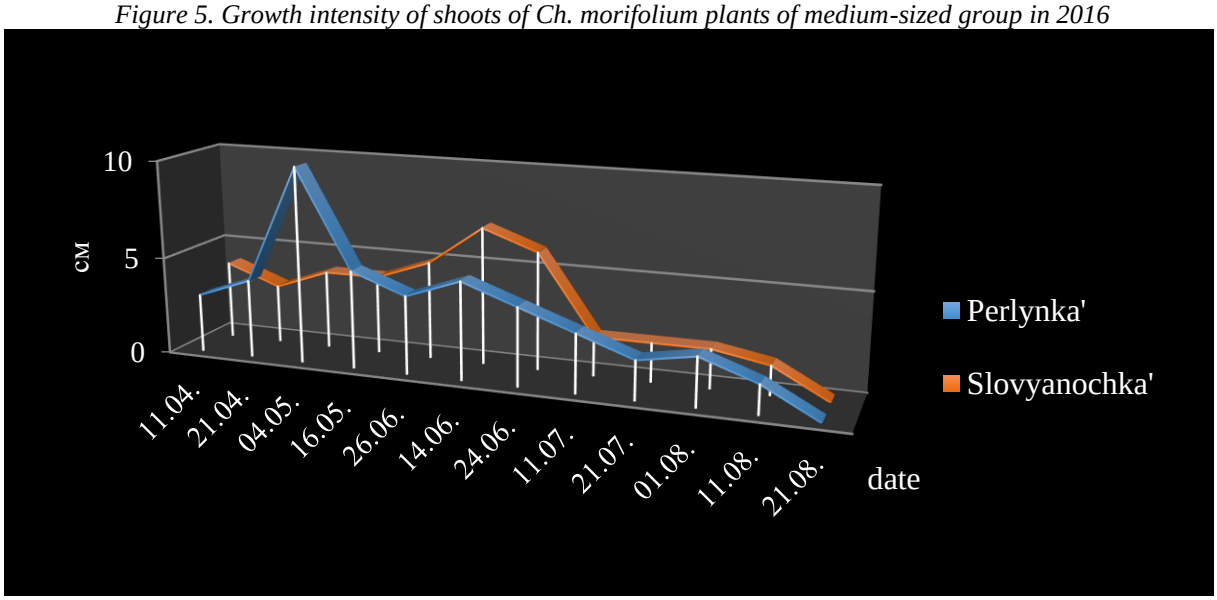


Figure 6. Growth intensity of shoots of Ch. morifolium plants of the tall group in 2016

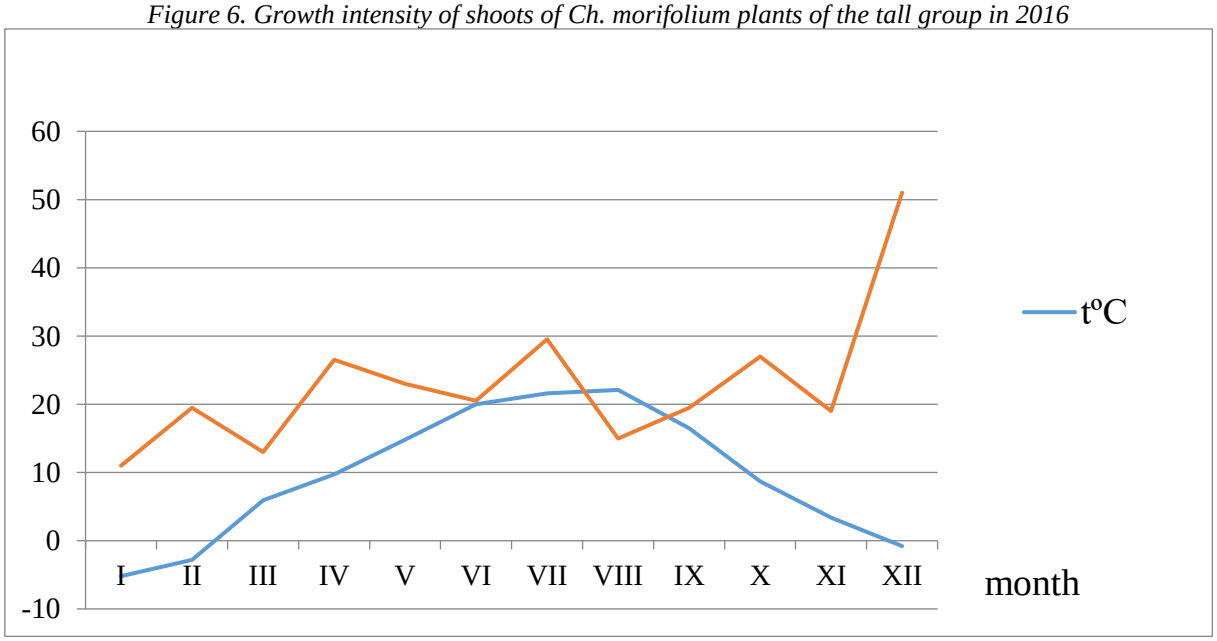


Figure 7. Climatodiagram of the research region in 2017

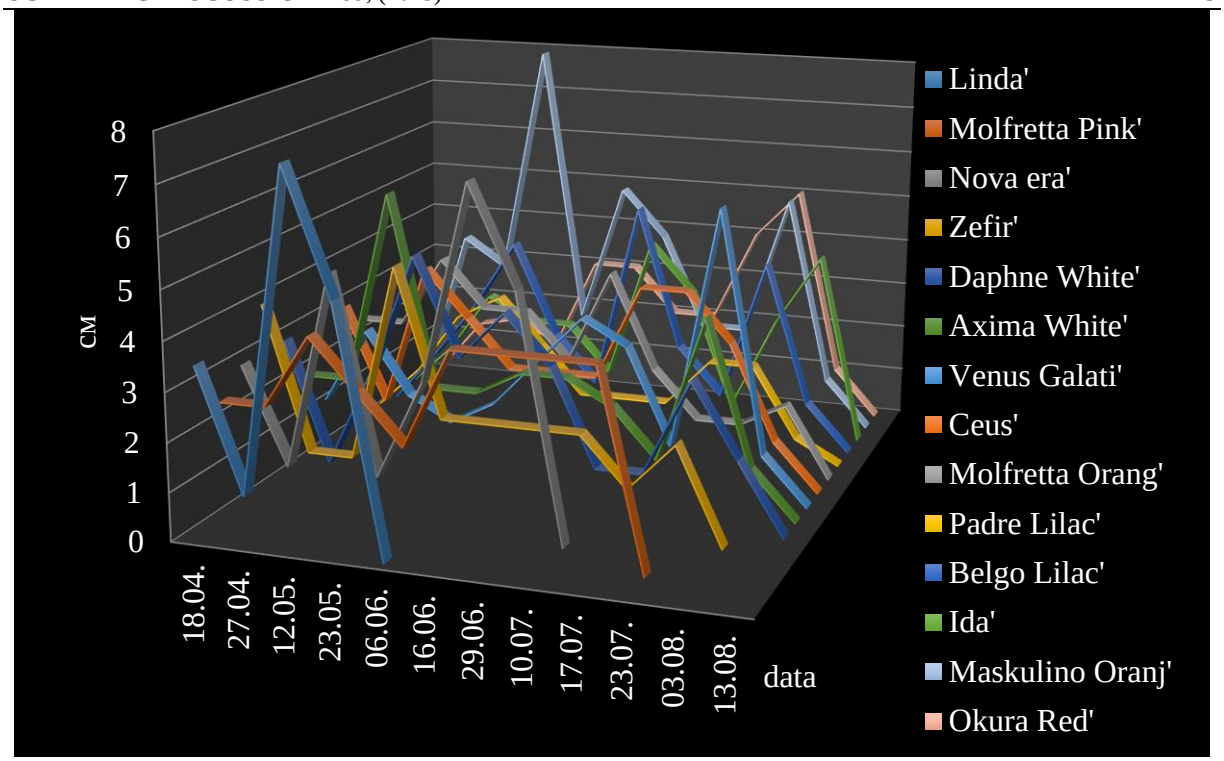


Figure 8. Growth intensity of shoots of Ch. morifolium plants of the multiflora group in 2017

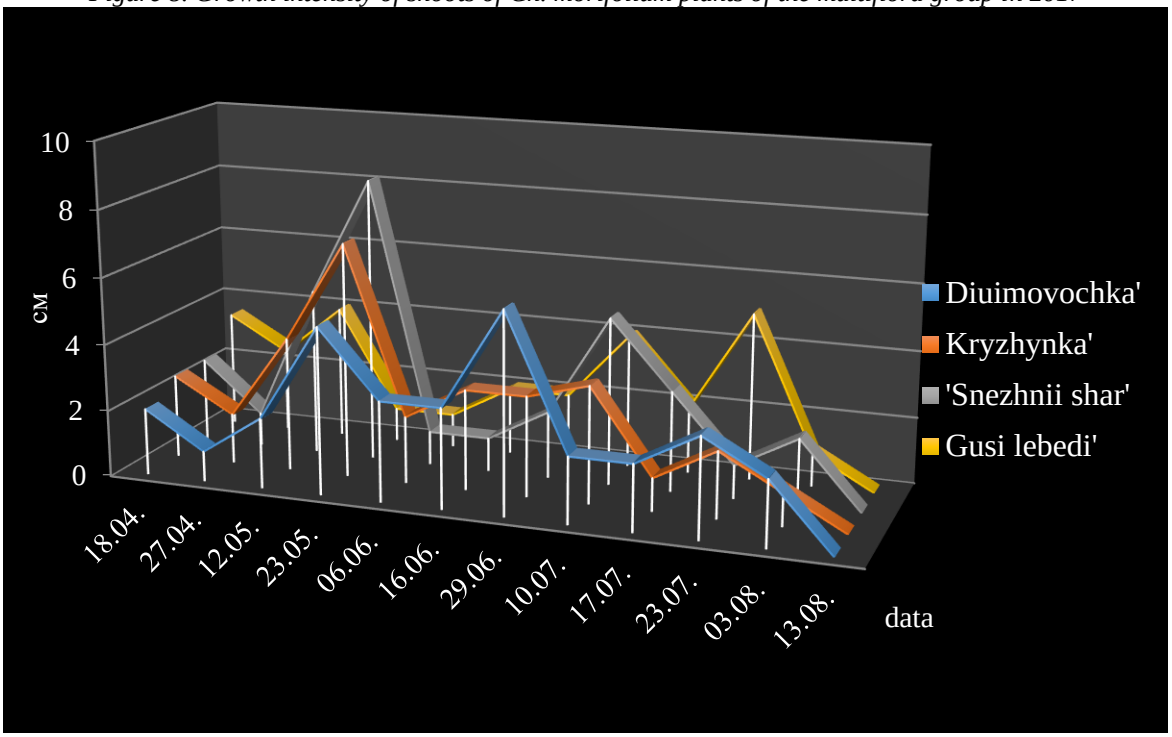


Figure 9. Growth intensity of shoots of Ch. morifolium plants of the undersized group in 2017

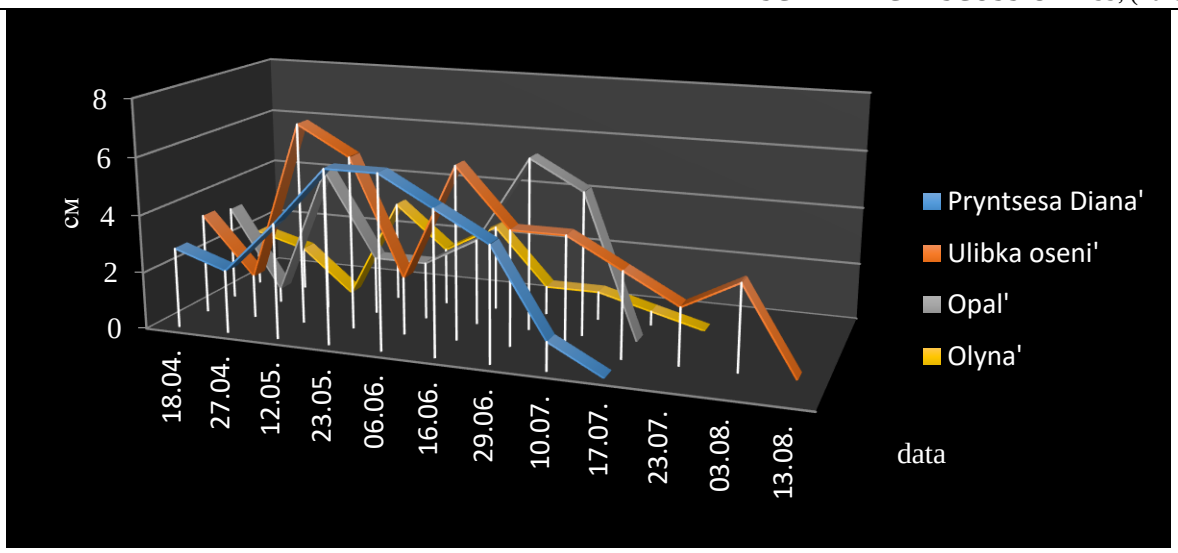


Figure 10. Growth intensity of shoots of Ch. morifolium plants of the medium-sized group in 2017

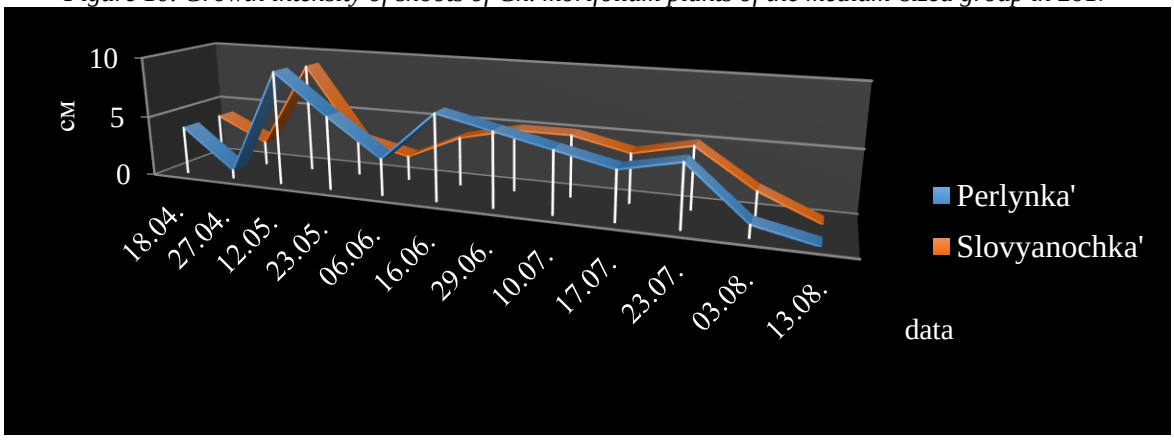


Figure 11. Growth intensity of shoots of Ch. morifolium plants of the tall group in 2017

The optimum temperature for inflorescence formation and development (generative phase) is +16°C +18°C, and temperatures higher or lower than the optimum (depending on the growth characteristics) delay these processes, which in turn leads to a delay in flowering. Depending on the summer and autumn temperatures, the flowering calendar of the studied varieties shifts from 5 to 25 days. According to the flowering period, we divide the studied varieties into three groups: early (III decade of June, July, August), medium (September, I decade of October), and medium-late (II-III decade of October) (Table 4).

Table 4

Flowering time of plants of the studied varieties of *Ch. morifolium*

Variety	Years of research					
	2016		2017		2018	
	beginning	ending	beginning	ending	beginning	ending
			early			
'Linda'	20.06.	01.08.	29.06.	10.08.	25.06.	12.08.
	02.09.	01.10.	17.09.	15.10.	10.09.	12.10.
'Nova era'	02.08.	05.09.	10.07.	13.08.	25.06.	01.08.
	30.09.	20.10.	16.09.	23.10.	10.09.	01.10.
'Opal'	15.07.	26.08.	10.07.	28.08.	01.07.	15.08.
	24.09.	01.11.	26.09.	20.10.	10.09.	01.11.
			medium			
'Snezhnii shar'	04.09.	01.11.	16.09.	19.11.	01.10.	13.11.
'Molfretta Pink'	05.09.	01.11.	23.08.	01.11.	10.09.	01.11.
'Zefir'	05.09.	23.10.	16.08.	23.10.	14.10.	13.11.
'Daphne White'	30.08.	20.10.	15.09.	10.11.	03.10.	25.10.
'Axima White'	30.08.	20.10.	02.09.	15.10.	05.09.	22.10.
'Molfretta Orang'	07.09.	29.10.	23.08.	01.11.	10.09.	01.11.
'Padre Lilac'	12.09.	20.10.	22.09.	09.11.	17.10.	13.11.
'Maskulino Oranj'	05.09.	25.10.	08.09.	20.10.	30.08.	30.10.
'Okura Red'	05.09.	03.11.	08.09.	02.11.	05.10.	13.11.
'Gusi lebedi'	04.09.	25.10.	07.09	20.10	10.10	31.10.
'Perlynka'	09.09.	12.10.	28.09.	20.10.	09.10.	13.11.
'Pryntsesa Diana'	07.09.	20.10.	17.07.	24.10.	17.09.	27.10.
			medium-late			
'Ceus'	04.10.	12.11.	20.10.	22.11.	22.10.	13.11.
'Belgo Lilak'	30.09.	13.11.	12.10.	16.11.	17.10.	13.11.
'Ida'	01.10.	13.11.	12.10.	16.11.	12.10.	13.11.
'Diuimovochka'	30.09.	10.11.	10.10.	19.11.	05.10.	13.11.
'Kryzhynka'	01.10.	13.11.	20.10.	19.11.	05.10.	13.11.
'Slovyanochka'	15.10.	13.11.	20.10.	19.11.	16.10.	13.11.
'Ulibka oseni'	12.09.	27.10.	18.10.	16.11.	01.10.	13.11.
'Olina'	20.10.	13.11.	16.10.	16.11.	18.10.	13.11.
'Tricky White'	—	—	01.10.	16.11.	27.09.	13.11.

Note: ▭ — repeated flowering.

However, despite fluctuations in weather conditions, plants under introduction acquire vegetative and generative morphological characteristics inherent in the variety. The generative phase of plant development ends mainly with flowering, and no seeds are formed. The exception is 2015, when plants of the varieties 'Nova era' and 'Gusi lebedi' were fertilized by free crossing.

Therefore, according to the introduction success scale of Smolinska M. O., the growth of monocarpic shoots of the studied plants was assessed as normal, flowering was massive annually, and fruiting was absent.

Under the conditions of introduction, the growth and development representatives of the genus also depends on the genetic ability of plants to resist diseases and pests. The most destructive plant diseases of the studied varieties of *Ch. morifolium* include Fusarium wilt (*Fusarium oxysporum* Schl.); powdery mildew (*Oidium chrysanthemi* Rab. and *Erysiphe cichoracearum* DC. f. chrysanthemi Jacz.); leaf septoria (species of the genus *Septoria*), and verticillium. Every year, from 50 to 100% of plants of the varieties 'Daphne White', 'Okura Red', 'Venus Galati', 'Ceus', 'Belgo Lilak', 'Tricky White', 'Snezhnii shar' are affected by these diseases. For example, plants of the varieties 'Venus Galati' and 'Belgo Lilak' are affected by parasitic fungi of the genus *Fusarium* Link with the onset of dry, hot weather, which leads to the development of the disease Fusarium wilt. In this disease, the roots of plants die off, the stem brown and gradually dries, the leaves curl and fade.

Also, during the study of these varieties, rot was detected - the causative agent of which is *Rhizoctonia solani* Khun. Symptoms of the disease include loss of turgor, the appearance of a creamy coating on the lower part of the stem, yellowing of the lower tier of leaves, rotting of the roots and root collar. When affected by this pathogen, damage is usually localized at the soil surface level, resulting in plants dying or stunting. The disease is caused by high soil moisture and high acidity, as well as prolonged cultivation of plants in one place.

Up to 75% of the plants of varieties 'Ida', 'Opal', 'Pryntsesa Diana' are resist ant to diseases and pests. Plants of the varieties 'Linda', 'Molfretta Pink', 'Nova

era', 'Olyna', 'Axima White', 'Diuimovochka', 'Perlynka', 'Ulibka oseni', 'Kryzhynka', 'Slovyanochka', 'Gusi lebedi', 'Molfretta Orang', 'Padre Lilac' are occasionally damaged individually, and 'Zefir', 'Maskulino Oranj' are not damaged.

According to M. O. Smolinskaya's scale of plant introduction success, one of the main indicators is frost resistance. But given the ecological and biological characteristics of the plants under study, we believe that this indicator is not limiting. Over the years of research, we have not noted any negative impact of critical low temperatures on plants in the autumn and winter. Therefore, this methodology for assessing the success of the introduction of *Ch. morifolium* plants, in our opinion, should be supplemented with three indicators: resistance to soaking in the winter-spring period (III decade of February — March), drought resistance, and decorativeness (Table 5). When assessing drought tolerance, we used the five-point scale of G. M. Shestachenko, T. V. Falkova [20], but in our studies the highest score was given to plants that are most resistant to drought (Table 5).

Table 5

Supplemented indicators in assessing the success of the introduction of the *Ch. morifolium*

Ball	**Indicators of successful implementation**		
	resistance to soaking	**drought tolerance**	**decorativeness**
1	soaks up to 50% of plants annually	complete or almost drying out of the aerial part of the plant	plants do not acquire varietal decorative characteristics
2	soaks up to 50% of plants periodically	damage is very severe, accompanied by massive drying out of shoots and loss of decorativeness	deviations in one or more decorative traits from the established varietal ones in 50% of plants
3	soaks up to 25% of plants periodically	severe damage: massive drying out of leaves, death of single shoots or their tops, flowering is suspended until precipitation falls	deviations in one or more decorative traits from the established varietal ones in 25% of plants
4	single soaking, periodically	weak damage: loss of turgor, curling of leaves and yellowing of a small amount of them in the lower part of the plant with the restoration of decorative effect after watering	deviations in one decorative trait occur singly from the established varietal ones
5	do not soaking	no damage	all plants of the variety comply with the established varietal characteristics for the main decorative features

Table 6 The level of adaptation of *Ch. morifolium* plants according to ten traits

Level of adaptation

The species is promising, stable in introduction. High level of adaptation.

The species is promising, but not sufficiently stable (weak seed and vegetative reproduction). Medium level of adaptation.

The species is unpromising, not sufficiently stable, and lacks self-renewal. Low level of adaptation.

The species is unpromising and unstable. It falls out after 2-3 years of cultivation. It has not adapted.

It is the ex situ resistance to soaking of plants in winter and spring that is a determining factor in the success of the introduction, as our region is characterized by the alternation of frequent thaws and temperature drops during this period. The accumulated moisture does not penetrate into the lower soil layers, but accumulates in the upper ones. As a result, many plants die.

The summer period of our region is characterized by a dry growing season with critically high temperatures in the daytime (up to +40ºC) and uneven distribution of precipitation (Figure 2, 7). As a result, the studied plants are affected by drought, which is manifested in the loss of turgor by the leaves of 'Opal', 'Molfretta Pink', 'Molfretta Orange', 'Venus Galati', 'Okura Red', 'Linda'. This loss is restored slowly, until the end of the growing season. In some cases, the turgor in the leaves was not restored at all, which led to their death. Therefore, plants of these varieties need systematic watering, three times a week in the morning. Plants of the varieties 'Daphne White', 'Pryntsesa Diana', 'Slovyanochka', 'Maskulino Oranj', 'Snezhnii shar' are relatively resistant to drought. During the drought period, the leaves lost their turgor, which was restored during artificial irrigation or rain. Plants of these varieties are sufficiently watered twice a week.

The main prerequisite for the creation of the collection of *Ch. morifolium* varieties is their valuable decorative traits, which are manifested in the habitus of plants, in the shape of leaves, in a wide range of colors of inflorescences, and in long flowering. Due to flowering, the studied plants provide decorative effect to the exposition areas of the Sofiyivka Dendrological Park from June to November (Table 4). Among the collection there are varieties with repeated flowering 'Linda', 'Nova era', 'Opal'. It is the plants of these varieties that provide decorative effects on the sites both in summer and in autumn. Plants of other varieties complement the color scheme of the exposition plots due to their ability to preserve varietal characteristics under conditions of introduction. However, the ability to preserve and manifest varietal traits depends not only on the *ex sity* conditions, but also on the age of the plants. Since plants have a short life span, it is necessary to periodically (in

the third year of plant ontogeny) carry out vegetative propagation of plants. We carry out propagation in two ways: by cutting green cuttings in protected ground and by dividing the bush. The rooting rate of green cuttings is 80% to 95%. The best time for dividing the bushes of the studied varieties is April - May and September. At other times, the division of bushes is possible, but the plants need additional care: watering 3-4 times a week, shading. In the presence of an average daily temperature above +5°C and in the absence of frost, division is possible — in March of 'Okura Red', 'Ceus', and in the first decade of October — of 'Okura Red', 'Ceus', 'Molfretta Pink', 'Linda'.

Thus, the above-described traits allow us to assess the level of adaptation of *Ch. morifolium* plants to the conditions of introduction and determine the group of plant prospects (Tables 6, 7).

Table 7.

Evaluation of the success of the introduction of *Ch. morifolium* varieties

Variety	Signs										Total score	Group of promising
	1	2	3	4	5	6	7	8	9	10		
'Pryntsesa Diana'	4	5	1	4	3	5	2	5	3	5	37	II
'Linda'	3	5	1	3	3	5	2	2	5	4	33	II
'Molfretta Pink'	4	5	1	5	4	5	2	5	3	4	38	II
'Nova era'	4	5	1	4	4	5	2	4	3	5	37	II
'Zefir'	4	5	1	4	4	5	2	4	4	4	37	II
'Olyna'	4	5	1	3	5	5	2	2	4	5	36	II
'Daphne White'	3	5	1	3	4	5	2	4	4	5	36	II
'Okura Red'	2	5	1	5	1	5	2	4	5	4	34	II
'Axima White'	3	5	1	5	1	5	2	5	3	4	34	II
'Diuimovochka'	4	5	1	5	4	5	2	3	4	5	38	II
'Maskulino Oranj'	5	5	1	5	4	5	4	5	4	5	43	I
'Perlynka'	4	5	1	3	5	5	2	2	5	5	37	II
'Venus Galati'	5	5	1	5	4	5	2	5	4	5	41	I
'Ceus'	3	5	1	4	1	5	2	3	3	5	32	II
'Belgo Lilak'	3	5	1	4	1	5	2	4	3	4	32	II
'Ida'	3	5	1	4	1	5	2	3	4	4	32	II
'Tricky White'	4	5	1	4	3	5	2	3	4	5	36	II
'Ulibka oseni'	4	5	1	4	1	5	2	3	4	4	33	II
'Kryzhynka'	4	5	1	5	4	5	4	4	4	5	41	I
'Slovyanochka'	5	5	1	5	4	5	4	5	4	5	43	I
'Snezhnii shar'	5	5	1	5	4	5	4	5	5	5	44	I
'Gusi lebedi'	5	5	1	5	1	5	4	5	5	5	41	I
'Molfretta Orang'	5	5	1	4	4	5	2	4	4	5	39	II
'Padre Lilac'	4	5	1	4	4	5	2	4	3	5	37	II
'Pryntsesa Diana'	4	5	1	4	4	5	2	3	4	5	37	II

Note: signs: 1 — growth of a monocarpic shoot; 2 — flowering; 3 — fruiting; 4 — vegetative reproduction; 5 — resistance to diseases and pests; 6 — frost resistance; 7 — vitality and self-renewal; 8 — resistance to soaking; 9 — drought resistance; 10 — decorativeness.

Discussion

Under the conditions of introduction, the plants of the studied varieties of *Ch. morifolium* do not form seeds, although they go through a full development cycle. This can be explained by the research of Fan Wang, Feng-Jiao Zhang, Fa-Di Chen, Wei-Min Fang and Nian-Jun Teng [22] on the self-compatibility or self-incompatibility of *Ch. morifolium* cultivars. They concluded that the compatibility index between the 24 cultivars they studied ranged from 0.04-87.50 %. In the end, only 10 varieties produced seeds. So, based on the above, we can assume that the varieties we studied are selfincompatible, as they do not bear fruit under the conditions of introduction.

Since the ability of *Ch. morifolium* plants to resist diseases is one of the main indicators of the success of plant introduction, we focus on this issue. Due to climate change, rising atmospheric temperatures, many diseases attack the plants under study, which in turn causes a decrease in the decorative effect of plants or leads to the death of the plant itself. Powdery mildew is one of them. In our research, we identified the causative agent of this disease, *Oidium chrysanthemi*. Michael Bradshaw, Uwe Braun, Monika Götz, Jamjan Meeboon and Susumu Takamatsu [2] reassessed and assigned *Oidium chrysanthemi* to the genus *Golovinomyces* with the species name *Golovinomyces chrysanthemi*. Researchers analysing the disease also point to the pathogen Golovinomyces artemisae. In our research, this pathogen was not detected. Another common disease is spotting caused by *Alternaria alternata* (Fr.) Keissl. [15, 24] which affects the whole plant, leaf spot caused by *Nigrospora oryzae* Fetch. [19], Fusarium blight — a root disease caused by *Fusarium oxysporum* Schlecht. [11] and Verticillium wilt caused by *Verticillium dahliae* Kleb. [5]. These diseases were also noted in our studies [4].

N.I. Duisenova and S. Ghani, analysing the success of the introduction of Chrysanthemum L. plants, concluded that plants in Mangistau (arid conditions) overwinter without the need for additional shelter [8]. In our studies, under temperate climate conditions, frost resistance is also not a limiting factor in the success of the introduction of *Ch. morifolium* plants.

Conclusions

The growth and developmental peculiarities of 24 cultivars of *Ch. morifolium* were studied in the conditions of the National Dendrological Park 'Sofiyivka' of the National Academy of Sciences of Ukraine. On the basis of the obtained results, the cultivation of the studied plants was evaluated according to ten indicators in the conditions of introduction. As a result, the groups of plant prospects were determined. Plants of the varieties 'Maskulino Oranj', 'Venus Galati', 'Kryzhynka', 'Slovyanochka', 'Snezhnii shar', 'Gusi lebedi' belong to the first group of prospects with the sum of points 41-44, to the second group with the sum of points 32-39 — 'Opal', 'Diuimovochka', 'Perlynka', 'Pryntsesa Diana', 'Linda', 'Molfretta Pink', 'Nova era', 'Zefir', 'Olyna', 'Daphne White', 'Okura Red', 'Axima White', 'Ceus', 'Belgo Lilak', 'Ida', 'Tricky White', 'Molfretta Orang', 'Padre Lilac', 'Ulibka oseni'.

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