






Assessing the Growth and Flowering Prospects of *Callistephus chinensis* (L.) Nees Varieties in the Voronezh Region

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ABSTRACT

This study evaluates the performance of *Callistephus chinensis* (L.) Nees (common China aster) varieties in the Voronezh region, Russia. Phenological observations were conducted, and the effects of different planting schemes on morphometric traits were analyzed. Germination energy and seed germination rates of 'Beautiful Day Creamy White' and 'Matsumoto Yellow' were 70-80%. All varieties bloomed earlier than reported by the breeders. Early flowering varieties ('Beautiful Day' and 'Benary's Princess Yellow') bloomed between 96-103 days, and medium-flowering varieties ('Lady Coral,' 'Balloon Yellow,' 'Matsumoto Yellow') bloomed between 104-115 days. Flowering duration lasted 31-35 days for medium-flowering varieties and 40-42 days for early flowering varieties. Matsumoto Yellow showed the tallest plants under different planting schemes (20×30: 63.3; 25×30: 70.8; 30×30cm: 75.8cm) and in containers (61.0cm). The largest inflorescences were observed in 'Beautiful Day Yellow' (6.1cm, 20×30cm), 'Lady Coral Creamy White' (5.7cm, 25×30cm), 'Balloon Yellow' (7.1cm, 30×30cm), and 'Benary's Princess Yellow' (5.2cm, container-grown).

Keywords: Common China aster, Garden aster, Chinese aster, Variety, Planting scheme, Ornamental crops, Flowering

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INTRODUCTION

Common China aster (*Callistephus chinensis* (L.) Nees), also known as annual aster, Chinese aster or garden aster, is an annual herbaceous plant that is widely used in ornamental horticulture, urban and private landscaping, along with other representatives of the Aster family (*Asteraceae*) (Orlova et al., 2020; Kosheleva & Orlova, 2021; Pashutin et al., 2022; Kosheleva & Orlova, 2022; Pashutin et al., 2022; Shtyrkhun, 2023; Kozlova, 2023; Kozlova & Akhmetova, 2023). This crop begins flowering towards the end of summer and continues until the onset of frost, which allows for its use in expanding the range of autumn-flowering plants. The variety of colors and undemanding requirements make it a versatile choice for use in landscaping flower beds, garden beds, and pot culture, as well as for cutting (Shchegrinets, 2007; Svyatkovskaya et al., 2022).

As a cultivated plant, *C. chinensis* was introduced to Europe from China in the 18th century. Initially, the inflorescences had only blue, pink and purple colors, but

breeding efforts have since produced plants with white, yellow and additional color variations. Aster breeding has been actively pursued in Germany since the mid-19th century, and is currently carried out in various European countries, including Denmark, the Netherlands, France, Germany, Poland and the Czech Republic (Phetpradap, 1992). Some of the most renowned aster breeders of the varieties are the companies Satimex, Benary (Germany), Sakata Seeds (Japan), Greenex, Queen Genetic, (Denmark), and Floranova (England).

In Russia, aster breeding efforts began in the 1930s at the All-Russian Institute of Crop Production named after N.I. Vavilov (VIR) (Shchegrinets, 2007). Currently, *C. chinensis* breeding in Russia is centered at the Federal Scientific Center for Vegetable Growing, its Voronezh Vegetable Experimental Station branch (Chugaeva, 2021). According to available sources, there are now up to 4000 varieties, with more than 180 varieties are registered in the State Register of the Russian Federation (State Commission of the Russian Federation for Testing and Protection of Breeding Achievements, 2023).

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C. chinensis exhibits significant morphological variation depending on the variety. For convenience, the aster classification proposed by Petrenko (1973) is currently employed, which is based on flower structure, inflorescence shape, shrub height, and economically valuable characteristics. According to this classification, *C. chinensis* varieties are divided into three classes, ten types, and 44 cultivars. These varieties vary in height (ranging 20 to 90cm), the number of inflorescences per plant (from 5 to 100), inflorescence size (2 to 16cm), and shape. These varieties vary in height (20 to 90cm), number of inflorescences per plant (5 to 100), inflorescence size (2 to 16cm) and shape. Additionally, the timing of flowering varies among varieties, occurring between 80 to 130 days after planting. Based on the degree of inflorescence doubling, varieties are categorized as non-double, semi-double, double, crown, and thick-double (The methodology of conducting tests for distinctness, uniformity and stability).

The inflorescence shape of *C. chinensis* can be flat, flat-rounded, hemispherical or spherical (Petrenko, 1973). Representatives of the *Asteraceae* family exhibit a phenomenon known as false doubling, in which turning tubular flowers transform into lingual ones. Notably, a higher degree of doubling in the plant correlates with a lower percentage of seeds that set. Each basket can contain between 10 to 200-300 seeds, with germination viability lasting 2-3 years (Kotov & Ostryakova, 2013; Kuzicheva et al., 2022). *C. chinensis* prefers light soils with neutral acidity (pH KCl: 6.5 to 7.5) and requires fertile condition with a minimum of 50 m³/ha of organic matter. This species is a cold-resistant, tolerating frosts down to -3 to -4°C. It is photophilic and requires at least 6 hours of sunlight per day; in hot climates, some shading is beneficial. The optimal temperature range for growth is 20 to 30°C during the day and 15 to 17°C at night. The plant thrives with moderate watering (Sokolova & Bochkova, 2017). Variety testing of *C. chinensis* has been conducted across various natural and climatic conditions throughout Russia (Shchegrinets, 2007; Orlova et al., 2020; Borisova & Vladimirova, 2022; Svyatkovskaya et al., 2022; Vladimirov et al., 2023). However, the specific growth and development characteristics of certain varieties in the Chernozem zone of Russia remain insufficiently studied, indicating a need for further research.

The purpose of the research was to investigate the growth characteristics of selected *C. chinensis* varieties in the natural and climatic conditions of the Voronezh region, Russia.

MATERIALS & METHODS

The research was conducted in Borisoglebsk, Voronezh region, Russia during the years 2022-2023. The soils in this region are predominantly sandy loam chernozem, characterized by an average composition of 80-82% sand fractions, 10% silt, and 8-10% clay. August was the hottest month in 2022 with an average temperature of +24.3°C, while January was the coldest, averaging -5.5°C. The minimum temperature recorded in March 2022 did not fall below -22°C, and the maximum reached +33°C in July. Slight frosts were observed in May, while the first significant

frosts occurred in October. The total annual precipitation in 2022 was 637mm, compared to the average annual precipitation of 486mm. The average annual temperature for the year was +7.90°C, while the average during the research period was +8.35°C. The growing season lasts from April to October. Based on the ratio of precipitation and evaporation, it is classified as having insufficient moisture, with a hydrothermal coefficient (HTC) of 0.8 (Aderikhin, 1963; Agro-climatic Resources of the Voronezh Region, 1972; WeatherArchive.ru, 2023).

The study focused on seven varieties of common China aster (*Callistephus chinensis* (L.) Nees) as research objects: Beautiful Day Yellow, Beautiful Day Creamy White, Lady Coral Yellow, Lady Coral Creamy White, Balloon Yellow (originator: Satimex Quedlinburg GmbH); and Benary's Princess Yellow (originator: Ernst Benary Samenzucht GmbH) and *Matsumoto Yellow* (originator: Sakata Seed Corporation).

Seeds (100 pieces per variety) were sown on May 21. Seedling emergence was observed 5-8 days later, with seedlings reaching the phase of the first true leaves before being transplanted into pots. The planting was carried out on June 23. Plant care included regular watering and weeding. Germination and germination energy were checked according to GOST 24933.2-81 "Seeds of flower crops: Methods for determining germination and germination energy" (Methods of State Variety Testing of Agricultural Crops, 1968). The Lady Coral Yellow variety, with a planting scheme of 25×30cm, was adopted as a control variant. The layout of plots was conducted according to the method described by Trifonova et al. (1994), with a systematic arrangement of treatments. Variance analysis was performed using the Microsoft Office Excel 2016 software package. The reliability of the research results was assessed using the smallest significant difference at the 5% significance level (Dospekhov, 2011).

The assessment of ornamental, economic, and biological qualities was conducted on a 100-point scale, based on a comprehensive set of economic and ornamental features outlined in the Methodology of State Variety Testing of Agricultural Crops (Ministry of Agriculture of the USSR, 1968). Phenological observations were carried out according to generally accepted methods (Yurkevich et al., 1980; Vladimirov et al., 2023). A total of 28 variants were studied, with six repetitions for each, resulting in a total of 168 registered plants

RESULTS & DISCUSSION

The viability of *C. chinensis* seeds is primarily influenced by their shelf life, with 1-2-year-old seeds exhibiting the highest germination rates. Additionally, varietal characteristics and growing conditions play significant roles in seed performance. Previous studies have highlighted the impact of varietal traits on seed productivity among different varieties of common China aster (Shevel & Rudnik-Ivaschenko, 2015). Unfortunately, seeds, particularly those of less popular varieties, often remain in stock when sold. In some cases, reserve stocks can exceed 50% or more when purchasing common China aster seeds. During the research

period, the germination energy and germination rates of the studied varieties were recorded (Table 1).

The timing of mass germination varied by variety, ranging from 5 to 8 days after sowing. The data indicated that the Beautiful Day Creamy White variety exhibited the highest germination rate at 82%, accompanied by a germination energy of 81%. The Matsumoto Yellow variety demonstrated a germination energy of 70% and a germination rate of 72%. In contrast, the Benary's Princess Yellow variety showed significantly lower results, with a germination energy of 45% and a germination rate of 52%. In the control variety, Lady Coral Yellow, had a germination energy of 47%, and a germination rate of 49%. The Beautiful Day Yellow variety matched the germination rate of 49% but had a slightly lower germination energy of 43%. Compared with the control, the Lady Coral Creamy White variety exhibited a reduced germination rate of 45% and a

germination energy of only 40%. The Balloon Yellow variety recorded the poorest performance, with a germination energy of 32%, germination rate of 40% (Fig. 1).

Thus, when purchasing seeds of the Lady Coral, Beautiful Day Yellow, Balloon Yellow varieties, it is advisable to acquire 60% of the required amount as reserve stock. For the Matsumoto Yellow and Beautiful Day Creamy White varieties, it is recommended to limit the reserve seeds to no more than 30% of the total needed.

It is important to consider the timing of flowering onset when calculating the sowing dates to ensure flowering occurs within the desired timeframe (Table 2). The varieties Lady Coral, Balloon Yellow, Matsumoto Yellow are classified as mid-season bloomers (designated as late blooming). Whereas the Beautiful Day and Benary's Princess Yellow varieties are categorized as early bloomers, with medium flowering times as specified by the originators.

Table 1: Germination Energy and Germination Rates of Various *C. chinensis* Varieties in the Voronezh Region

Variety	Germination energy (%)	Germination rate (%)	Seedling Emergence After Sowing (days)
Lady Coral Yellow	47	49	5
Lady Coral Creamy White	40	45	8
Beautiful Day Yellow	43	49	7
Beautiful Day Creamy White	81	82	5
Benary's Princess Yellow	45	52	7
Balloon Yellow	32	40	8
Matsumoto Yellow	70	72	5

Table 2: Average Duration of Growth Phases and Interphase Periods of Various *C. chinensis* Varieties in the Voronezh Region

Variety	Budding (days from sowing)	Flowering (days from sowing)	Duration of Flowering (days)	Duration of Vegetation (days)
Lady Coral Yellow	98	111	31	142
Lady Coral Creamy White	95	107	32	139
Beautiful Day Yellow	117	100	40	140
Beautiful Day Creamy White	117	100	42	142
Balloon Yellow	122	105	35	140
Benary's Princess Yellow	114	97	42	139
Matsumoto Yellow	126	109	33	142

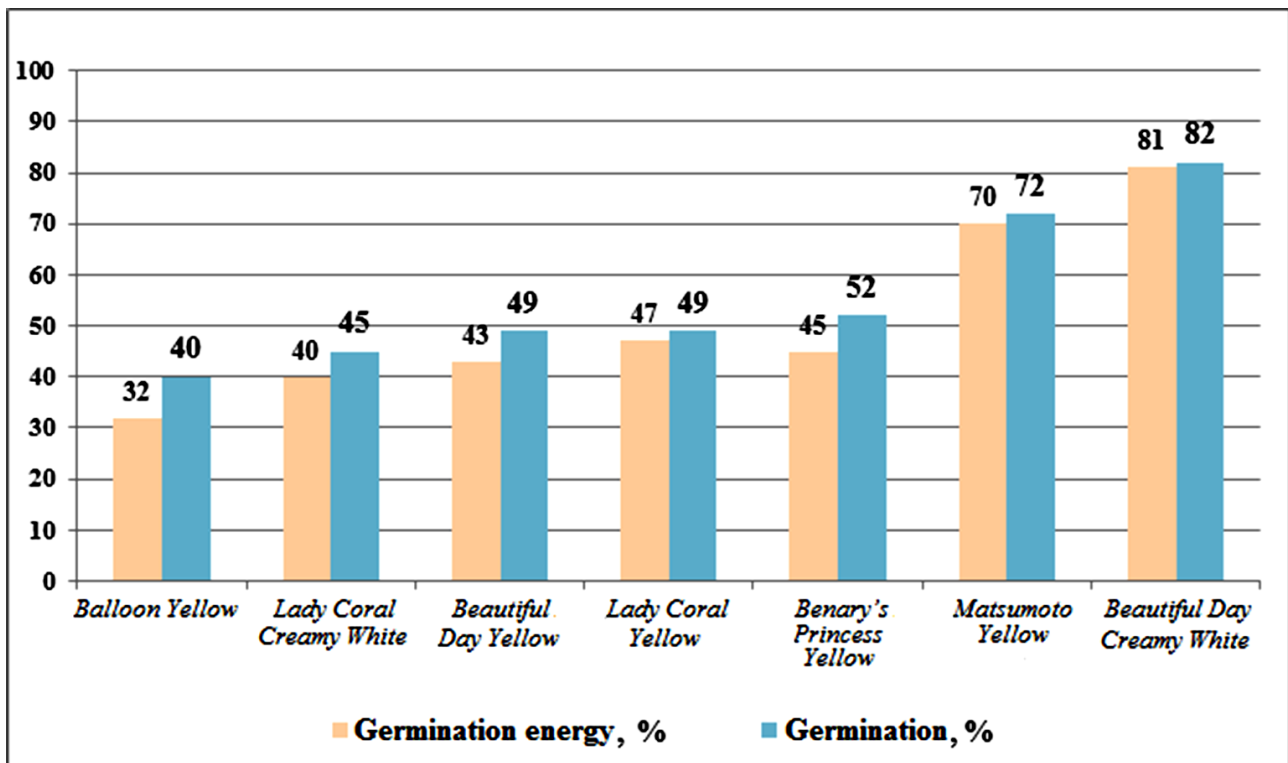


Fig. 1: Germination Energy and Rate of *C. chinensis* Varieties in the Voronezh Region (%).

The time of the beginning of flowering has shifted to an earlier time in the varieties analyzed. The reason for the shift in flowering dates may be high temperatures during the growing season, which are known to accelerate plant development. However, unfavorable conditions in mid-October, including heavy rains and subsequent night frosts, halted all plant growth by October 15. It was, therefore, not possible to determine the maximum flowering period of the individual varieties in this study. The time of the start of flowering therefore played a major role in the assessment of the flowering period in our experiment (Fig. 2).

The flowering duration of the varieties ranged from 31 to 42 days, influenced by factors; such as germination date and time from germination to flowering. For clarity, the duration of flowering is illustrated in Fig. 3. The control variety had the shortest flowering time of 31 days, primarily due to the longest duration from germination to flowering, which was 111 days. The duration of flowering of the Lady Coral Creamy White variety was 32 days. Although it flowered slightly earlier at 107 days compared to the control, its later germination date (three days after the control) negatively impacted the overall flowering duration.

Despite the early and uniform germination, the

Matsumoto Yellow variety had an average flowering time of 109 days and a blooming period of 33 days. The Balloon Yellow variety is on the verge of early and medium-flowering varieties (105 days) in terms of flowering start had a flowering period of 35 days due to late germination. In contrast, the Beautiful Day variety series exhibited early blooming, with a duration of 100 days from germination to flowering. Due to a two-day difference in germination timing, the Beautiful Day Yellow variety exhibited flowering duration of 40 days, while Beautiful Day Creamy White and Benary's Princess Yellow both varieties flowered for 42 days. The variety Benary's Princess Yellow had the shortest period from germination to flowering (97 days), though its germination was delayed by 2-3 days compared to both the control group and Beautiful Day varieties. Based on these results, Benary's Princess Yellow and the Beautiful Day series can be classified as earlier flowering varieties. On the other hand, Balloon Yellow, Matsumoto Yellow, and Lady Coral varieties showed later flowering patterns. It's important to note that growing location can affect flowering duration. Research by Yagdarova and Voskresenskaya (2013) found that asters grown in residential and industrial areas flowered for 51 days, compared to 42 days for those grown in suburban areas.

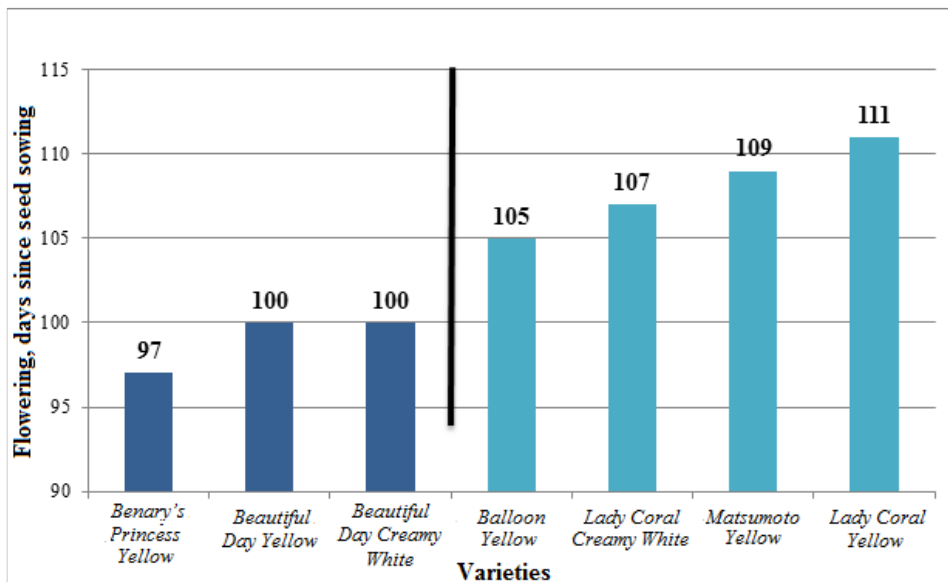


Fig. 2: Duration of the Interphase Period from Seedling Emergence to Flowering in Various *C. chinensis* Varieties in the Voronezh Region (Days).

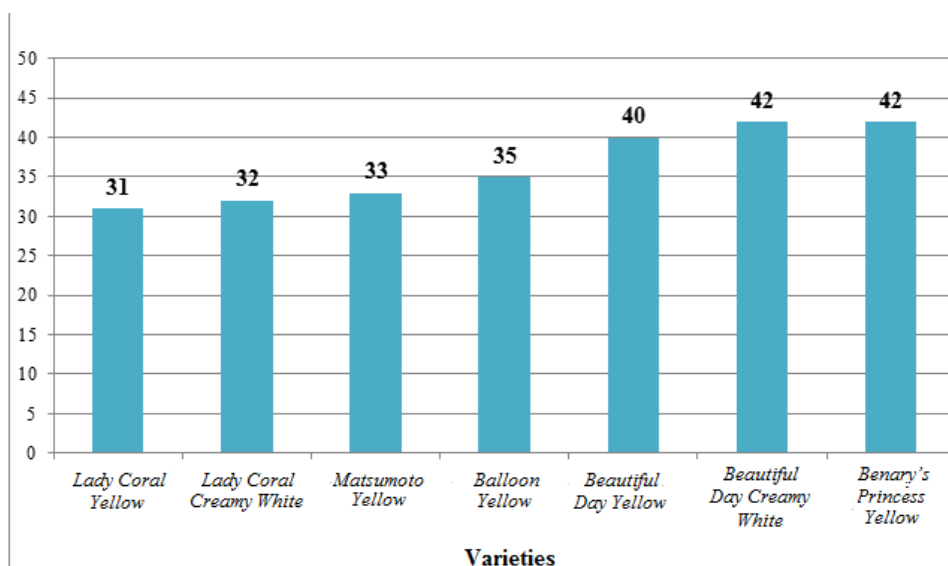


Fig. 3: Duration of Flowering of Various *C. chinensis* Varieties in Voronezh Region (days).

The height of the plants may depend not only on the variety, but also on the soil and climatic conditions. When using the common Chinese aster in landscaping, the height of the plants cannot be used as a clear criterion for ornamentalness, as it is when used as a cut flower. Nevertheless, this is an important criterion, as the choice of variety and its companions in the flower garden depends on it. The height of the common Chinese aster varieties was determined during the flowering period (Table 3).

Table 3: Average Height (cm) of *C. chinensis* Plants of Various Varieties in the Voronezh Region Based on Variety and Planting Scheme

Variety	Planting scheme			
	20×30cm	25×30cm	30×30cm	Container
Lady Coral Yellow	50.8	57.5	54.3	40.0
Lady Coral Creamy White	24.8	43.8	44.3	47.0
Beautiful Day Yellow	52.0	46.3	56.5	55.0
Beautiful Day Creamy White	41.7	44.5	40.0	50.0
Benary's Princess Yellow	44.8	48.0	44.0	57.7
Balloon Yellow	43.3	34.0	32.5	57.0
Matsumoto Yellow	63.3	70.8	75.8	61.0

The height of the Lady Coral Yellow variety is 50-60cm in open ground and 40cm in protected ground. The plants in the open ground had a higher ornamental value, which suggests that this variety prefers a more open planting. The Lady Coral Creamy White variety had an outdoor height of 29.8cm when planted 20×20cm and 40-45cm when planted more freely. The height of the plants in the container was 48.3cm. It can, therefore, be concluded that this variety is also preferable when planted more freely. There were no significant differences in the bush height of the plants of the Beautiful Day variety group in the various planting schemes. The height of the plants of the Beautiful Day Yellow variety is 45-55cm. This variety can be recommended for both outdoor and container cultivation. The height of Balloon Yellow plants when planted at 20×30cm and in a container was 43cm, when planted at 25×30cm – 25.8cm, 30×30cm – 32.8cm. Consequently, this variety prefers a denser planting of 20×30cm and performs well in container culture. The height of plants of the Benary's Princess Yellow variety is 40-50cm outdoors and 57cm in protected soil. This variety also performs better when planted more densely and especially in protected soil. The Matsumoto Yellow variety had a height of 60-65cm when planted more densely (20×30cm) and in a container. When planted more freely, the height of the plants increased to 70-75cm. The plants of this variety are characterized by a rather sprawling bush and reach their maximum height when planted freely.

For more accurate data processing and reliable conclusions, an analysis of variance of plant height of common Chinese aster was performed at a significance level of 5. Cultivar characteristics had the greatest influence on plant height, the proportion of the factor was 46.12%. The share of the planting plan in the plant height was 5.73%. The combination of variety characteristics and planting scheme had an effect of 14.4%. A considerable proportion of the influence (33.75%) is due to random factors (Fig. 4).

Our research specifically focuses on how plant height varies with different planting patterns. Therefore, data on the influence of varietal characteristics, planting patterns, and fertilizers are crucial for our conclusions. Recent research by Kozinskaya (2024) shows how specific fertilizers can enhance China aster quality. Kozinskaya (2024) reported

that using Siliplant and Potassium Humate fertilizers resulted in highly ornamental Chinese aster seedlings. These seedlings were notable for their bright coloration, high survival rate after transplanting, and high adaptability to open ground conditions. The variety Lady Coral Yellow has a significant difference in plant height between the containerized culture and the 25×30cm and 30×30cm planting schemes; the variety Lady Coral Creamy White is significantly different in plant height from the other planting schemes when planted at 20×30cm; the varieties Beautiful Day Yellow and Beautiful Day Creamy White showed no significant difference in plant height at different planting schemes; the Balloon Yellow variety has a significant difference in plant height between the 20×20cm and 25×30cm planting schemes and between the 25×30cm scheme and container culture; the Benary's Princess Yellow varieties have a significant difference in plant height between the 20×30cm planting scheme and container culture and the 30×30cm planting scheme and container culture; the Matsumoto Yellow variety has a significant difference in plant height between container culture and the 30×30cm planting scheme. In the open field, there is a significant difference between the 20×30cm and 30×30cm planting schemes.

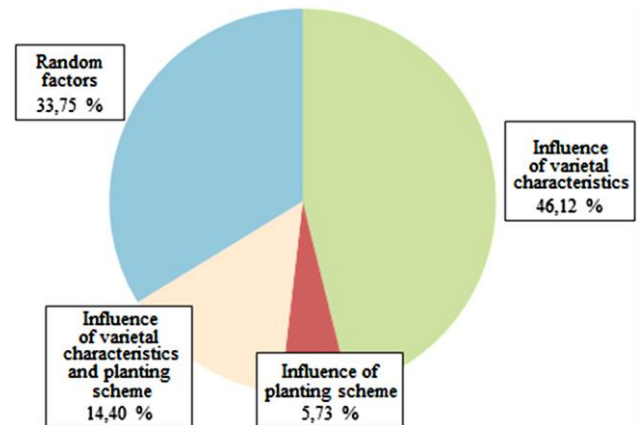


Fig 4: Influence of Factors on the Height of *C. chinensis* Varieties in the Voronezh Region (%).

The diameter of the inflorescences of the common Chinese aster is between 3 to 15cm, depending on the variety. The size of the inflorescences of a variety also depends strongly on the soil and climatic conditions under which it grows. As part of our research, the size of the inflorescences of the common Chinese aster was determined in different varieties. The diameter of the inflorescences was measured during the time of mass flowering of the plants (Table 4).

Table 4: Average Height (cm) of *C. chinensis* Plants of Various Varieties in the Voronezh Region by Variety and Planting Scheme

Variety	Planting scheme			
	20×30cm	25×30cm	30×30cm	Container
Lady Coral Yellow	4.1	4.2	4.2	5.2
Lady Coral Creamy White	4.9	5.7	5.3	5.3
Beautiful Day Yellow	6.1	4.8	5.7	4.6
Beautiful Day Creamy White	5.1	5.2	6.0	5.2
Benary's Princess Yellow	4.8	5.2	5.4	5.6
Balloon Yellow	5.3	5.0	7.1	4.7
Matsumoto Yellow	2.8	2.6	3.0	3.4

The Lady Coral Creamy White variety has a maximum inflorescence diameter of 5.7cm for a planting scheme of 25×30cm. The minimum size of the inflorescences in a planting scheme of 20×30cm is 4.91cm. The Beautiful Day Yellow variety had a maximum inflorescence diameter of 6.1cm for a planting scheme of 20×30cm. The minimum size of inflorescences was observed in a 25×30cm planting scheme and in container culture and was 4.6-4.8cm. The maximum size of the inflorescences of the Beautiful Day Creamy White variety was observed when planted at 30×30cm and was 6.0cm. No significant differences in the diameter of the inflorescences were observed in the other varieties. The Balloon Yellow variety also had a maximum inflorescence size when planted at 30×30cm. The average inflorescence size for this variety was 7.1cm. In protected soil, the inflorescence size is minimal 4.7cm. In open ground, Benary's Princess Yellow had a larger average inflorescence diameter the greater the distance between plants. However, the maximum size of the inflorescences in the protected soil was 5.6cm. The minimum diameter of the inflorescences of this variety was 4.8cm when planted 20×30cm. The Matsumoto Yellow variety had a significantly larger inflorescence diameter when planted in protected soil, namely 3.4cm. In open ground, the diameter of the inflorescences was 2.6-3.0cm. The Lady Coral Yellow variety has a maximum inflorescence diameter of 5.2cm and was grown in a container culture. In the open field, the diameter of the inflorescences was 4.0-4.2cm and there was no significant difference between the different planting schemes.

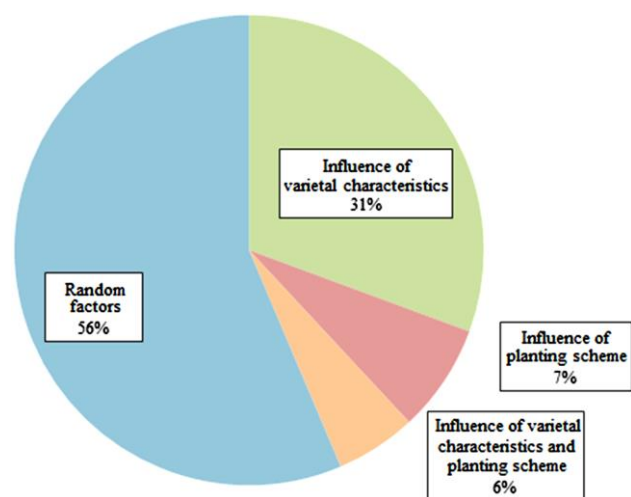


Fig 5: The proportion of the influence of factors (%) on the characteristics of common China aster inflorescences.

In the work of Pasko (2010), the question of the diameter of inflorescences of some annual flowering plants, including aster, was analyzed. In the course of his research, the author found that the number of flowers on plants increased by more than one and a half to two times when the seeds were treated with ECAW (electrochemically activated water) before sowing.

According to the results of two-factor analysis of variance revealed that random factors, which were not accounted for in this study, had the most significant impact

on inflorescence diameter, contributing 56.38% of the variation. Varietal characteristics accounted for 30.62% of the variation, whereas. The planting scheme influenced inflorescences diameter by 7.45%. The interaction of varietal characteristics and planting patterns contributed 5.55% to the variation in inflorescence size (Fig. 5).

Under the conditions of our research, the differences in the diameter of the inflorescences within the variety with different planting methods are important for us. In the Lady Coral Yellow variety, the diameter of the inflorescences in the container differed significantly from that in the open field. There were no significant differences between the different planting schemes when planted in the field; for the Lady Coral Creamy White variety, there were no significant differences in inflorescence diameter when planted at 30×30cm and in a container. For the other planting options, there were significant differences in inflorescence size; for the Beautiful Day Yellow variety, there were no significant differences between planting in a 25×30cm scheme and in a container. The remaining planting schemes differed significantly in inflorescence size; the inflorescence size of the Beautiful Day Creamy White variety differed significantly from the other options when planted at 30×30cm. The other planting schemes did not differ significantly from each other; the Balloon Yellow variety showed a significant difference in inflorescence size in a containerized culture from the open field. In the field, the size of inflorescences differed significantly between a 30×30cm planting and a denser planting of 20×30cm and 25×30cm; the size of inflorescences in the Benary's Princess Yellow variety differed significantly from the other planting options in a 20×30cm planting. When planted at 25×30cm, the size of the inflorescences did not differ significantly from the 30×30cm planting. When planted at 30×30cm and in a container, there were no significant differences; the Matsumoto Yellow variety differed significantly in inflorescence size from containerized plants planted outdoors. In the open field, the plants with a planting scheme of 25×30cm and 30×30cm differed significantly from each other.

Conclusion

An evaluation of the germination energy and rate of *C. chinensis* seeds showed that the varieties Beautiful Day Creamy White and Matsumoto Yellow in the Voronezh region had a germination rate of 70-80%, while the other varieties analyzed had a germination rate of 40-50%. The low germination rate must be taken into account when planning the volume of seed to be purchased. Judging by the time of onset of flowering, all varieties started flowering earlier than indicated by the originators. For example, the varieties Beautiful Day and Benary's Princess Yellow flowered early (96-103 days). The varieties Lady Coral, Balloon Yellow and Matsumoto Yellow flowered in the middle period (104-115 days). The time of flowering has a great influence on the duration of flowering, especially under unfavorable conditions in autumn. In our study, the flowering period was 31-35 days for the varieties with an average flowering period Lady Coral, Balloon Yellow, Matsumoto Yellow and 40-42 days for the early flowering varieties Beautiful Day, Benary's Princess Yellow. Matsumoto

Yellow had the highest height in all trial variants: 63.3cm for a planting scheme of 20×30cm, 70.8cm for a planting scheme of 25×30cm and 75.8cm for a planting scheme of 30×30cm – when grown in a container. The plants of the Beautiful Day Yellow variety had the largest inflorescence diameter in a 20×30cm planting scheme; the Lady Coral Creamy White variety in a 25×30cm planting scheme; the Balloon Yellow variety in a 30×30cm planting scheme; and the Benary's Princess Yellow variety when grown in a container.

In conclusion, it should be noted that scientific research on the cultivation of the common Chinese aster in the conditions of the Chernozem zone of Russia is insufficient. It is necessary to study the phenology of asters in different regions to expand and supplement the information available so far. Planting patterns also need to be researched, as they can vary depending on the group and variety. This in turn affects the expression of the ornamental characteristics of the plants.

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