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PAULOWNIA TOMENTOSA – NEW SPECIES FOR THE INDUSTRIAL LANDSCAPING

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Abstract
Paulownia tomentosa is a large arborescence tree that planted mostly for its fast growing wood and look. The purpose of our work was to study the biological characteristics of Paulownia tomentosa in the conditions of the Zaporizhzhia city. The research was conducted with trees grown from seeds and planting in 2000-2019. Much attention was given to measurement parameters of growth and development, and also physiological parameters of frost resistance Paulownia tomentosa under the conditions of industrial city. The study of the features of the morphology of the vegetative organs of Paulownia tomentosa at the city of Zaporizhzhia showed that the investigated indicators of biomorphological development are within the normal range. According to the physiological - biochemical parameters of the carbohydrate metabolism of Paulownia tomentosa plants in autumn and winter, we can conclude that its winter resistance well enough. Paulownia tomentosa adapts to the climatic conditions of the city of Zaporizhzhia. According to the acclimatization level Paulownia tomentosa is well acclimated in the industrial city of Zaporizhzhia species with a high decorative qualities. So, it can be recommended for landscaping both parks and squares and streets of the industrial city.

Keywords: flower, grows rate, landscape, lignin, Paulownia, starch

1. INTRODUCTION

Paulownia tomentosa is a large arborescence tree that planted mostly for its fast growing wood and look. Country of origin of this plant is China. An unusual exotic look is given to the tree due to big lilac violet flowers. *Paulownia tomentosa* Steud. is a new, perspective species for usefor the landscape design at Ukrainian cities.(Dubova et al., 2005) A tree adapts oneself to the municipal districts. Wide crown of trees provide dense shade in parks and public gardens, seating areas, enriches their crisp air, especially in industrial cities, where it - muddy due to mostly exhaust - gass. From the largenesses of leaves, one tree of *Paulownia* can take in to 22 kg of CO_2 every day, and to distinguish 6 kg of oxygen. Depending on the state of environment of *Paulownia* can attain in a height to a 30 m. It can develop as a large bush. *Paulownia* is a not simply exotic tree. It is difficult to enumerate all areas this plant is used in that. Wood, leaves, flowers - they all have properties that humanity can avail. The rapid increase of tree is exceptionally suitable for the receipt of biomass for short time. All organs of plant are used: stem, leaves (Khivrich et al., 2019). Growing of *Paulownia tomentosa* in Zaporizhzhya was begun with one copy in Zaporizhzhya municipal botanical garden. Then scientists and students of Zaporizhzhia Nanional University began to grow a *Paulownia tomentosa* from seed.

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The purpose of our work was to study the biological characteristics of *Paulownia tomentosa* in the conditions of the Zaporizhzhia city.

2. MATERIALS AND METHODS

The research was conducted with trees grown from seeds and planting in 2000-2019. Much attention was given to measurement parameters of growth and development, and also physiological parameters of frost resistance *Paulownia tomentosa* under the conditions of industrial city.

Phenological observations was conducted during decade (in 2010 - 2019) on generally accepted botanical and ekologo – geographical methods, description of seasons and subseasons of year was conducted on the basis of methods of Andrienko T.L and Filonova K.P., Nukhimovskoi (Beydeman, 1954; Yeremeyev, 2003; Andrienko, 2005). Periodicity of leadthrough of observations in spring- summer a season was made 3-4 days, and in other seasons of year – 5-6 days. These phenophases was fixed in study journals.

The content of starch and lignin was studied on annual shoots of plants that were taking from November to March. They were dried and shredded. To determine the starch we used the method of Pochynok (Pochynok, 1987). The dry plant material was extracted in a boiling water bath, filtered and hydrochloric acid solution was added and the optical density on FEC was measured with a red filter. The starch concentration was determined according to the calibration schedule.

The separation of lignin from other components of the plant is based on its resistance to acids. Lignin is separated from the related substances by the sequential treatment of the material with acetic acid, acetone, sulfuric acid. The lignin content was determined by the titrometric method. The prepared solution is titrated with a solution of Mor salt in the presence of phenylanthranilic acid until it changes the color from a cherry violet to green.

For study under a light microscope (CM, Biolar) the material was treated according to the conventional acetolysis method (Kokhno et al, 1994). Photos were taken on a USB Sigeta CAM-07 at 20x-200x magnification.

The level of success of introduction was determinate by the method of integral numerical assessment of the viability and prospects of introduction of woody plants based on visual observations (Kokhno et al, 1994)and the method of assessing the degree of acclimatization (Lapyn, 1973).

Kohno M. and Kurdyuk O. (Kokhno et al, 1994) combined the criteria of acclimatization estimation by the sum of the estimates and gave them a numerical value. The authors called this number acclimatization (A), it is the sum of the indicators of plant growth and resistance to negative environmental factors. The highest value of the acclimatization number (100) corresponds to the highest success rate of the introduction. To determine the acclimatization number, the authors proposed the following formula:

$A = P \times b + GR \times b + Zm \times b + Zc \times b,$

where:

P – growth rate; b – the coefficient of significance of the trait, taken on the basis of its value for the successful passage of the introduction process; GR – the indicator of generative development; Zm - index of winter resistance; Zc - the indicator of drought resistance.

3. RESULTS AND DISCUSSIONS

Annual observations of the seasonal rhythm of *Paulownia* showed that it starts and ends its vegetation late, an average in 230 days in the growing season.

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Based on the study of the growth dynamics of *Paulownia tomentosa* over 8 years, we found that the vegetative period begins in the last decade of April, and ends in November and lasts 230 ± 2 days depending on the year of observation. *Paulownia tomentosa* has an intense growth of shoots during June-October, which is an average of 1.81 cm per day in the main shoots and 0.81 cm per day in the side shoots. Growth of shoots continues throughout the growing season and ends simultaneously with the decline of number of leaves in the first week of November.

Table 1. Season rhythm of growth and development of generative and vegetative organs of Paulownia tomentosa

Year	Swelling of vegetative buds, dates	Opening of vegetative buds, dates	Start of grows, dates	leaf fall, dates	leaf activity, days	Blooming, dates	Flowers fall, dates
2010	15.04-20.04	20.04-22.04	22.04-25.04	07.11-9.11	201	-	-
2011	13.04-19.04	19.04-21.04	23.04-25.04	9.11-10.11	201	14.05-24.05	25.05-26.05
2014	11.04-15.04	16.04-18.04	20.04-22.04	10.11-12.11	208	05.05-14.05	17.05.-20.05
2016	07.04-09.04	10.04-13.04	15.04-17.04	10.11-13.11	214	22.04-03.05	08.05-15.05.
2018	11.04-13.04	14.04-16.04	17.04-19.04	14.11-15.11	213	26.04-02.05	03.05-05.05
2019	13.04-15.04	16.04-20.04	21.04-23.04	-	-	28.04-05.05	06.05-15.05

The study of the morphology of the vegetative organs of the *Paulownia* in the city of Zaporizhzhia showed that the investigated parameters of biomorphological development (height of the plant, length of annual growth, leaf plate size, number of leaves per year) are within the normal.
We observed the blooming of trees *Paulownia tomentosa* during years. For the first time large, pyramidal inflorescences - up to 30 cm in length - were hung, formed at the end of August 2009. But the blooming in the spring did not happen, because of severe winter with low temperatures, the buds died out. The buds, that was formed in the end of summer 2010, overwintered and blossomed in the spring of 2011. Flowers began to be formed on May 14-15 2011. The opening of buds is acropentally, on each inflorescence forms from 1 to 7 flowers. Full blooming lasted until May 19-20, on May 24-25, all the inflorescences were fall out.
Flowers of *Paulownia tomentosa* are bisexual, large, up to 6.4 cm in diameter, purple-blue, inside with a yellow strip, fragrant, with a bell-shaped calyx, slightly distorted, tubular, five-legged pitcher, with four double-stalk stamens and a pillar with a short column. Ovary consist of two ovules (Table 2, Fig. 1). Pollen grain elliptic, triborous with thin exine, they diameter is about 27-33 microns.

Table 2. Structure of flower of Pawlownia tomentosa

Number of flowers per one inflorescence, pc	Size of sertulum, cm	Size of trampet , cm	Size of limb, cm
27,2 ± 2,32	6,3 ± 0,07	4,4±0,04	1,8 ± 0,13

Fruit is a box containing a number of winged seeds. On 2016, 2018, 2019 years the start of flowering was on April due to warm spring. The development of generative organs of *Paulownia* is under the influences of temperature. Blooming does not occur after strong winters due to the buds were freezing.

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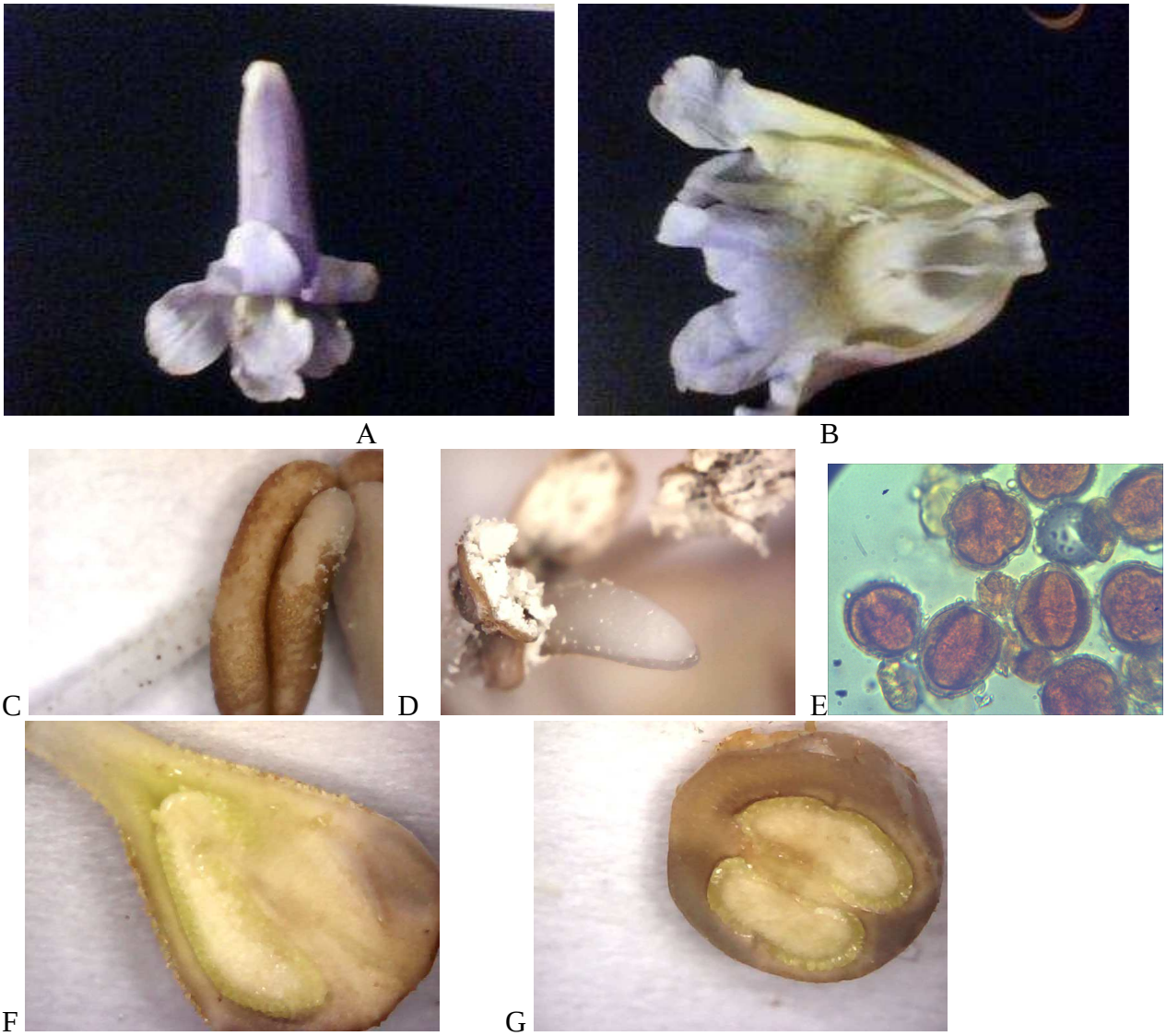

Figure 1. Structure of the flower: A. - Sertulum B. - Cross cut of sertulum C. - Anther. D. - Pollen on anther E. - Pollen grains . F. - Lengthwise sections cut of ovary. G. - Cross sections cut of ovary.

The dynamics of amount of carbohydrates is associated with the annual morphophysiological cycle of trees. For the determination of adaptation to low temperatures, the observing of the dynamics of starch during the preparation of plants for winter deserves special attention . The degree of starch hydrolysis correlates with adaptability to low negative temperatures.

It was established by our research that in the autumn the maximum of starch in *Paulownia tomentosa* is observed at the beginning of November (4.56%) During the winter months its amount decreases, in February its content is minimum (2.29%.) There is a second starch maximum in March. (3.28%) that coincides with the starts of sap flow (Fig.2).

One of the most common biopolymers in nature is lignin. These phenolic polymers have a great importance in the adaptation of plants to the adverse effects of the environment. Lignification increases with the action of adverse factors on the plant organism. In less cold-resistant species of

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plants the maximum content of lignin is in the tissues at the beginning of winter (December), and it decreases in early spring (March). According to our research, the maximum lignin content was observed in December — 3,02%, and in February it content was 3.19%, in March the content of lignin decreased to 2.38%, because of the processes of tissue delignification take place (Fig. 2).

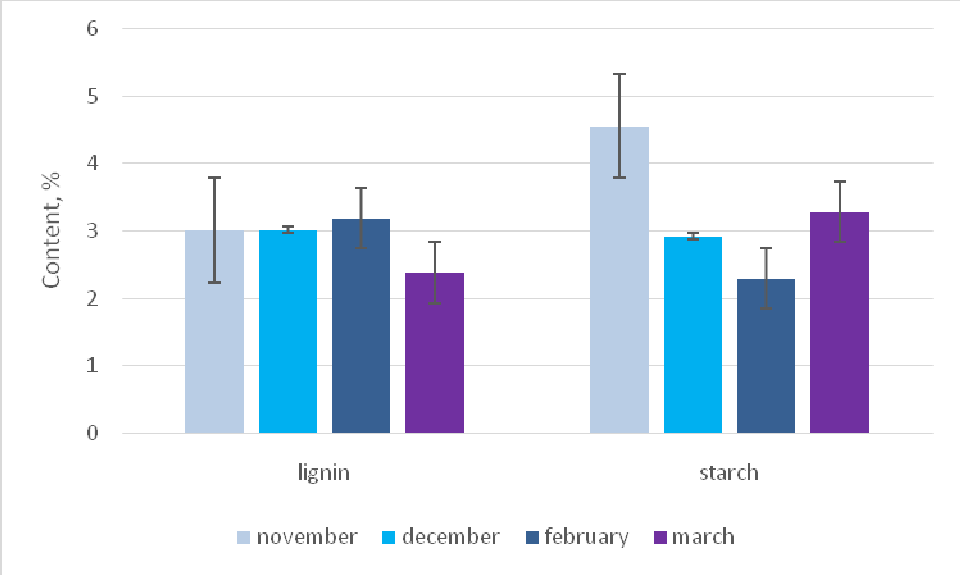

Figure 2. Content of starch and lignin during the season

To evaluate the success of the introduction of *Paulownia tomentosa*, we determined the acclimation level.

An estimation of indicators of growth, winter resistance, drought-tolerance and generative development was conducted (Table 3). The growth index is 5 points, winter resistance and drought tolerance is estimated at 4 points, and generative development at 3 points, as the blooming does not occur after the winter with extremely low temperatures. The accumulative number for *Paulownia tomentosa* is equal to

$$A = 5 * 2 + 3 * 5 + 4 * 10 + 4 * 3 = 10 + 15 + 40 + 12 = 77$$

Table 3. Level of success of the introduction of Paulownia tomentosa at Zaporizhzhia city

Grows rate, в=2		Generative development, в=5		Winter resistance, в=10		Drought resistance, в=3	
Description	Value	Description	Value	Description	Value	Description	Value
Excellent	5	Plants blooming and gives pods only when winter is warm enough. Seeds are germinate.	3	Partially freezes the tip of the annual shoot	4	Partially resistant (leaves are fall when temperature is very high)	4

By the indicators of the acclimatization level we can conclude that the degree of acclimatization approaching to the good one.

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4. CONCLUSIONS

Thus, the study of the features of the morphology of the vegetative organs of *Paulownia tomentosa* at the city of Zaporizhzhia showed that the investigated indicators of biomorphological development are within the normal range. That fact, that *Pauwlownia tomentosa* starts and ends vegetation late can affect on winter resistant of this plant.

According to the physiological - biochemical parameters of the carbohydrate metabolism of *Paulownia tomentosa* plants in autumn and winter, we can conclude that its winter resistance well enough. *Paulownia tomentosa* adapts to the climatic conditions of the city of Zaporizhzhia, as evidenced we can named the starch amount dynamics. Based on the study of the degree of lignification of the tissues of shoots *Paulownia tomentosa* can be considered as a medium frost resistance plant.

According to the acclimatization level *Paulownia tomentosa* is well acclimated in the industrial city of Zaporizhzhia species with a high decorative qualities. So, it can be recommended for landscaping both parks and squares and streets of the industrial city.

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