Assessment of propagation efficiency of Clematis L. green cuttings in Western Siberia

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Abstract. In recent years, clematis have become very popular in landscaping around the world. The representatives of this species are characterized by long-term decorativeness, a fast growth rate and a variety of forms. To meet the needs of urban landscaping, a large amount of planting material adapted to local conditions is required. In this regard, it becomes necessary to study individual parameters of their reproduction, taking into account the capabilities of producers of planting material in the region. The varieties that are well adapted to local climatic conditions, are stable decorative were selected as the objects of research. These are representatives of the Jacqueman groups (Rhapsody, Hagley Hybrid, Jerzy Popieluszko and Madame Baron Veillard) and Viticella (Purpurea Plena Elegans, Polish spirit, Ville de Lyon). The varieties Ville de Lyon (93%), Madame Baron Veillard (82%), Purpurea Plena Elegans (80%) have the highest root-forming ability. The propagation of cuttings is influenced by many factors such as the phenological phase of development during the harvesting of cuttings, the microclimate parameters in the artificial fog greenhouse and the varietal characteristics of the culture. In the future, it is necessary to work out the issues of deplantation of annual plants into containers for overwintering in protected ground.

1. Introduction

The sustainable development of agricultural sector is the important element of the overall task of human development. The balanced development of industry enterprises implies not only the development of industries related to the receipt of food products, but also the industries responsible for providing plants with high aesthetic qualities [1]. The interest in ornamental plants in the framework of the current project “Formation of a comfortable urban environment” in 2017 and numerous programs and projects included in it is especially relevant [2]. In the “Concept of long-term socio-economic development of the Russian Federation for the period up to 2020” and “National Security Strategy 2020” among the priorities are the improvement of the quality of life of citizens, ecology and rational nature management [3, 4]. In this regard, the important task is the creation of favorable environment and natural resource potential [2].

One of the important factors in the improvement of urban environment is the vertical space filling, along with the planar elements such as flower beds and lawns. Green walls, arches and other vertical elements affect human condition not only emotionally and aesthetically, but also significantly improve comfort indicators. They lower air temperature, wind force, heating of building facades. In addition, they do an excellent job with the lack of space for planting conventional crops [5].
The representatives of the genus Clematis have recently become one of the most popular plants in vertical gardening around the world, which are characterized by long-term decorativeness, rapid growth rates and are distinguished by originality and variety of forms. In total, about 50 species of the genus Clematis and a huge number of hybrids and varieties are grown [6,7].

In order to provide the urban environment with the necessary amount of planting material, producers need to know the characteristics of their reproduction. Despite the popularity of this species in Siberia, there is a problem of the high cost of planting material due to the difficult reproduction and the peculiarities of adaptation of species to climatic conditions. The issues related to the reproduction of culture are studied all over the world. The most relevant among them are the reproduction by green and woody cuttings, tissue culture in vitro and mechanisms of seed germination [8–11].

The production of planting material is one of the most important branches of horticulture. Scientific breakthroughs and technological developments in the field of cultivation and microclimate control systems are actively introduced into the process in order to increase the efficiency of plant reproduction and obtain a homogeneous planting material [12].

The purpose of the research was to assess the efficiency of reproduction of clematis varieties adapted in the conditions of Western Siberia by green cuttings in conditions of artificial fog, and determine the optimal parameters of the microclimate.

2. Materials and methods
The popular clematis varieties of the Jacqueman groups (Rhapsody, Hagley Hybrid, Jerzy Popieluszko, Madame Baron Veillard) and Viticella (Purpurea Plena Elegans, Polish spirit, Ville de Lyon) were selected as the studied material. The studied varieties showed good adaptation to the climatic conditions of Western Siberia, which was proved by winter hardiness score of 1-3 (according to P.I. Lipilin), a long flowering period (50-84 days) and vegetation (145-172 days). The features of biological development were determined according to the Methodology for state testing of agricultural crops. Ornamental Crops (1968) and Test Methodology for Distinctness, Uniformity and Stability. Clematis (2015) [13, 14].

The research was carried out in the Omsk region, which belongs to the southern forest-steppe of Western Siberia in 2015, 2017 and 2018 on the basis of the collection of perennial ornamental crops of the educational research and production laboratory “Gardening” of Omsk State Agrarian University. The cuttings were harvested from adult specimens of 5-9 years old during the period of intensive shoot growth (June 20-25), according to the recommendations of M.A. Beskaravaynaya. Indolylbutyric acid at a concentration of 50 mg / l was used as a root formation stimulator. The cuttings were rooted under conditions of artificial fog created by spraying water under high pressure from finely dispersed nozzles.

Propagation substrate was presented by a mixture of peat and sand (1: 1). The scheme of planting was in 7x4 cm ridges. The experiments were repeated three times. The presence of callus and roots was checked every 5 days. Every day at 9, 15 and 21 hours the temperature of the air and the substrate were recorded, the relative humidity of the air was determined. The studies were carried out according to the method of plant propagation by green cuttings [15, 16]. In autumn, the output of annual plants was recorded and deplanted into pots.

3. Results and discussion
The climate of the southern forest-steppe of the Omsk region is characterized as extremely continental. The distinctive features are usually hot summers with an average air temperature in July of + 19.4 °C, significant changes in daily temperatures up to 9-12 °C per day, uneven distribution of precipitation by months (an average of 358 mm per year) and cold winters (according to long-term data the sum of negative winter temperatures is -1982 °C, the average air temperature in January is -18.2 °C) in combination with a rather late accumulation of snow in recent years. In average, the frost-free period is 115 days.
The climatic conditions significantly affect the growth and development of grafters, overwintering and the passage of phenological phases. The cuttings were harvested annually at the same calendar dates, in some years the phenophases came earlier and the harvesting of the material coincided with flower-bud formation. For example, in 2017, during the cuttings, the budding phase - the beginning of flowering were observed in the varieties Hagley Hybrid, Jerzy Popieluszko, Purpurea Plena Elegans, Polish spirit, Ville de Lyon. In other years, in the third decade of June, the growth phase of the shoots was noted.

The quality of the planting material and its uniformity were determined by a number of indicators such as the growing conditions and the state of grafters, the microclimate during the period of root formation and the environmental parameters affecting the young plant after reproduction [12]. The microclimate is one of the main factors that determine the production of plants. The parameters for the studied period are shown in Figure 1.

Throughout the entire period of root formation in during studied years, the substrate temperature was 1-1.5 °C higher than the air temperature in the greenhouse. 2015 was the hottest year characterized by sharp changes in daily temperatures; these facts affected the microclimate indicators. Intensive heating of the substrate was observed in the first 10 days after planting; the temperature was 30.6 °C, which was 4.1-5.6 °C higher than in 2017 and 2018 respectively. Then, the decrease in temperature was noted in 2017-2018 or temperature drops of 2-7°С in 2015. Due to its high heat capacity, the substrate, in contrast to air, cooled and heated up more slowly, this created stable conditions during propagation of cuttings. The important role was played by the amplitude of temperature fluctuations; during the research years, it could change within 5 days from 21.9 to 30.6 °C. The relative humidity of the air was maintained by artificial fog system and was in the range of 92-96% in order to maintain vital processes in the leaves.

The Clematis cuttings were harvested annually on June 20-25. This usually coincided with the budding phase of Hagley Hybrid, Madame Baron Veillard, Ville de Lyon and flowering of the rest. In Western Siberia, the budding period of most varieties was observed in the first decade of June, and in some years in the third decade of May in Rhapsody and Purpurea Plena Elegans varieties.

The process of callus formation during propagation of clematis cuttings was practically not observed in 2015 due to the high temperature of the air and substrate. Over the entire study period, the formation of callus was noted in 2017 and 2018, when the substrate moisture was 2-3% higher during the propagation period, compared to 2015, and the air temperature dropped to 22.8-24 °C for 15 days. In addition, in 2015, sharp temperature fluctuations were noted during the first 10 days after planting, which affected the temperature of the substrate and air in the greenhouse, as well as the regeneration process. The external appearance of callus was recorded in 5-10 days after planting. The number of cuttings ranged from 20 (Hagley Hybrid) to 60% (Rhapsody).

The beginning of root formation was noted in 15-20 days after planting, depending on the microclimate and varietal characteristics. The most favorable year for propagation of cuttings was in
2018. It was characterized by more even temperature conditions in the first 20 days after planting. The beginning of propagation of cuttings was recorded on the 15th day. Root formation in 90% of cuttings occurred in 20-30 days and the number of rooted cuttings was 95% for Madame Baron Veillard, 93% for Ville de Lyon, 82% for Purpurea Plena Elegans, 79% for Hagley Hybrid, 79% for Hagley Hybrid - 70% in the most favorable 2018. On average, over the years of research, the number of rooted plants ranged from 70 (Jerzy Popieluszko, 2015) to 95% (Ville de Lyon, 2018). The exceptions were the years, when early growth of shoots and further phenophases were noted 1-2 weeks earlier than usual. In this regard, the formation of shoots with longer internodes and a smaller number of nodes was observed, which affected the amount of material harvested for reproduction. Such cuttings rooted longer and their number was 16-32% lower.

According to the obtained results, the varieties Ville de Lyon (93%), Madame Baron Veillard (82%), Purpurea Plena Elegans (80%) were characterized by a rather high root-forming ability (Table 1).

| Variety                        | Number of rooted cuttings to planted (%) | Yield of annual plants from the number of rooted (%) |
|--------------------------------|------------------------------------------|------------------------------------------------------|
| Hagley Hybrid                  | 79                                       | 89                                                   |
| Rhapsody                       | 71                                       | 74                                                   |
| Purpurea Plena Elegans         | 80                                       | 86                                                   |
| Madame Baron Veillard          | 82                                       | 74                                                   |
| Jerzy Popieluszko              | 73                                       | 70                                                   |
| Polish spirit                  | 76                                       | 80                                                   |
| Ville de Lyon                  | 93                                       | 93                                                   |

The rest of the varieties rooted from 71 to 79% of cuttings. The high rate of root formation often depended not only on the prevailing microclimatic conditions, but also on the phenological phase of plant development during the period of harvesting cuttings. The rather late regrowth of clematis in 2018 contributed to the later onset of budding and flowering phases, which coincided with the propagation period. In planted cuttings, rotting was less common and regeneration processes were faster. Thus, 74% of Rhapsody cuttings were rooted in 2018, which was 4% more than in 2015; 80% Jerzy Popieluszko (12% more), 89% Hagley Hybrid (21% more), 90% Madame Baron Veillard (18% more), 91% Purpurea Plena Elegans and Polish spirit (23% and 25% more, respectively), 96% Ville de Lyon (up 8%).

Thus, annual plants had a well-developed aboveground part and a fibrous root system with roots of the first and second orders. The yield of annual plants from the number of rooted ones was from 70 to 93%. The highest yield of annual plants was observed in the variety Ville de Lyon 93%, Hagley Hybrid 89% and Purpurea Plena Elegans 86%. The varieties Rhapsody and Madame Baron Veillard 74%, Jerzy Popieluszko 70% were less preserved. These varieties turned out to be more sensitive to changing conditions during the period of further development of the aboveground part and growth of the root system. The increased plants mortality was probably due to incorrect combination of parameters of increased moisture and low night temperatures in August up to 11-15 ° C. Significant changes in day and night temperatures contributed to plant rotting.

The root system of cuttings is one of the most important factors in plant propagation. In order to ensure optimal conditions for its development and better preservation of plants, the cuttings were deplanted into pots filled with substrate. The deplantation of rooted cuttings into pots is a necessary technique in the climatic conditions of Western Siberia, since plants of the first year of life are not able to overwinter in the open field. At this stage, there is increased plants mortality, depending on the variety, on average up to 46%.

The creation of optimal conditions for the development of root system, growth of aboveground part after propagation and adaptation of young plants during deplantation requires careful study in
order to prevent such increased plant mortality in the future. It may be necessary to experience different periods of plant deplantation after propagation or to provide other conditions for further growth and development.

4. Conclusion
The microclimate plays an important role in the propagation of green clematis cuttings. In the first 5-15 days after planting, high temperatures of air and substrate in the range of up to 30 °C stimulate internal regeneration processes in green cuttings. Moderate temperatures in the range of 25-27 °C are preferred for further root formation. At the same time, the optimal relative humidity should be maintained at 92-96%. The studied varieties of clematis are characterized by high propagation ability, not less than 71%. The period of root formation varies from 15 to 30 days. During propagation, clematis reacts to temperature drops in combination with overwetting, while callus formation is noted in 20-60% of cuttings. High propagation rate of green cuttings is not a guarantee the required amount of planting material. It is necessary to create optimal conditions for the further development of annual plants. The issues of replanting rooted plants for conservation during the winter period require further study. It is necessary to continue research of the features of regeneration and development of the root system of clematis with the support of the Center for Collective Use “Genetics of Grain Crops”.

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