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FROST HARDINESS OF MONUMENTAL PARKS IN THE CONDITIONS OF CENTRAL HIGHLAND AREA OF DNIPER RIVER

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The comparative analysis results of frost hardiness of woody exotic species that are concentrated in planted parks - monuments at the territory of Central highland area of Dniper river showed that the species are the most frost resistant.

Keywords: frost hardiness of exotic species, park monuments of landscape art.

The hardiness of a plant in autumn and winter period and especially in the period of induced dormancy in the extreme temperatures is one of the main indicators of acclimatization level that are connected with the notions of winter hardiness and frost hardiness. The notions are undoubtedly interdependent; however, they are interpreted by different authors in different ways. Taking into account that the planting of monumental parks of landscape art (MPLA) are developed mainly due to exotic species that grow naturally in various parts of the world where the climate indicators differ significantly from their analogues in central highland area of Dneper river (CHADR), the analysis of their hardiness is necessary in order to define the degree of their introduction in the area under research.

The aim of the research is comparative analysis of exotic species hardiness that grow at the territory MPLA CHADR. In order to identify the hardiness of 16 types of exotic species there were done laboratory research and comparative analysis with analogue indicators original type for CHADR - *Acer platanoides* L.

Research methodology. The study of hardiness was based on the results of postmortem examination after the frost penetration of shoots in the heat chambers by the method of

Potanin D.V., Horoholskoho V.V., Kitaev O.I., Bublik M.O. [4]. The research was pursued in laboratory Institute physiology NAASU where cold storage box «Frigera» was applied. Frost penetration was applied in the period of induced dormancy in the first ten-days of March in simulated temperatures -30 and -35^{o}C. The temperature was decreased during the frost penetration at a speed of 5^{o}C per hour. After the given temperature was gained, the examined samples were kept in such state during 6 hours. Frost penetration was carried with the temperature increase at a speed of 5-6^{o} C per hour.

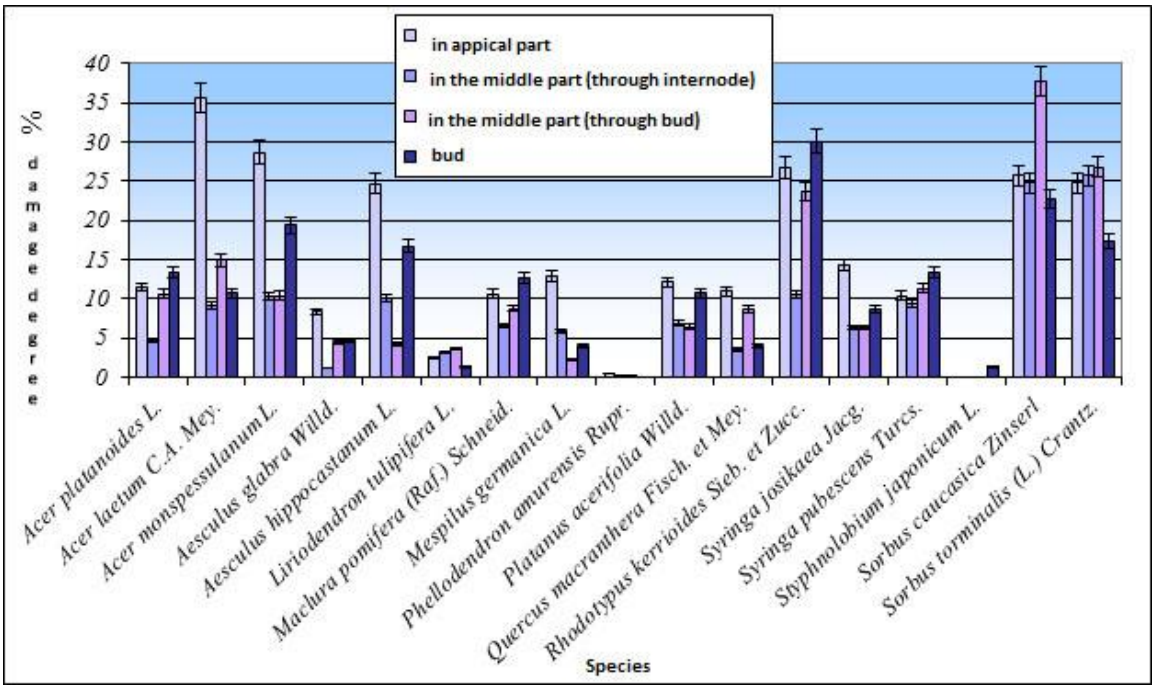
For the control process there were selected the shoots that were subjected to the effect of the low temperatures in artificially created plant association in essential conditions. In order to make the anatomic analysis of damage degree of tissue, samples were preserved during three weeks in cold premises in closed plastic bags. The transversal section of shoots were put into glycerin, laid out on the object plate and investigated under a microscope МБС-10 (MBS -10).

Research results. When analyzing the temperature regime and critically low temperatures of natural habitats area of distribution of exotic species that grow on the territory of the objects under investigation, one should pay attention to the difference in main indicators of some of them, especially to East Asian floral region species (*Phellodendron amurense* Rupr., *Acer laetum* C.A. Mey., *Rhodotypus kerrioides* Siebold et Zucc., *Styphnolobium japonicum* L.). The climate of the region has significant differences, first of all, in low temperature indicators in winter [2]. The climate of natural habitat of others can be vice versa considered similar to CHADR. Mostly, they are exotic species that are from Atlantic- North American floral region (*Liriodendron tulipifera* L., *Aesculus glabra* L. and *Maclura pomifera* (Raf.) Schneid.), and species that grow in bounds of two floral regions – Circumboreal and Iranian-Turanian

(*Sorbus caucasica* Zinserl, *Mespilus germanica* L., *Quercus macranthera* Fisch. et Mey., *Acer monspessulanum* L., *Sorbus torminalis* (L.) Crantz. (the last two grow only on the territory of Circumboreal floral region). One species originates from Mediterranean floral region - *Aesculus hippocastanum* L. Species *Platanus acerifolia* Willd. is hybrid of *Platanus orientalis* L. and *Platanus occidentalis* L., that naturally grow on the territory of Mediterranean and Atlantic-North American floral regions respectively.

Taking into consideration different climate conditions of habitats of natural increase in exotic species, the implementation of laboratory research with the aim to adaptat potential of plants in the introduction conditions is necessary for identification of its perspective in garden and park sector. In order to identify the potential frost hardiness of the researched exotic species, there was carried out laboratory frost penetration of shoots that were selected during induced dormancy period.

According to the research results of frost hardiness, damage of all shoot part at the temperature -25,1^{o}C (that is the lowest during the research period of 2009-2011) are absent only in *S. Japonicum (pic. 1).* Bud is not damaged only at Ph. Amurensis with insignificant damages of its shoots – from 0,2 till 0,5% at different parts. Apical part of shoots mostly damaged at *A. Laetum* - 35,6%,middle part is damaged (through internode) – at *S. Torminalis* (25,7 %). In addition to it, according to the analysis of damaged shoots of exotic species (*A. glabra, L. tulipifera, Ph. amurensis, Q. macranthera, S. japonicum*) they are less than among native species, among 9 of them – they range from 5,8 % to 10,5 % and only the damage of two (*S. caucasica, S. torminalis*) are in the bounds of 24,7-25,7 %. Insignificant difference (to 5%) in the damage of apical part between *A. Platanoides is* observed at *P. acerifolia* (12,1%) and *Syringa josikaea* Jacg. (14,3 %).

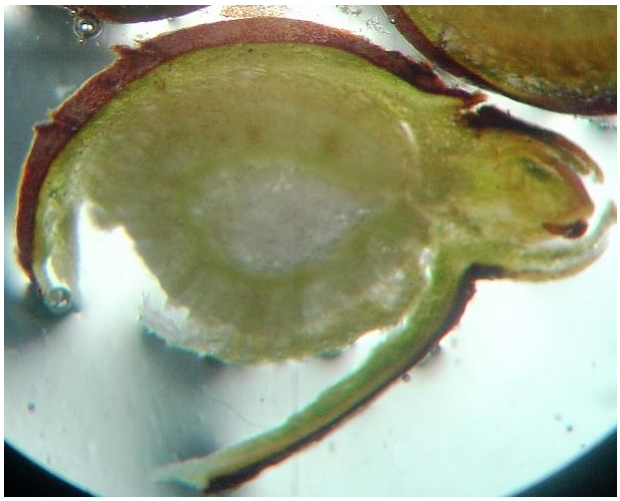


Pic.1. Tissue damage degree of different shoot parts of exotic species at temperature -25°C.

The damage degree of shoots in the middle part (through the bud) at the most investigated exotic species is less than at *A. platanoides*. Though, as an exception, one should pay attention to *S. caucasica* (37,8 %), *S. torminalis* (26,8 %), *Rh. kerrioides* (23,7 %), *A. laetum* (14,9 %) and *Syringa pubescens* Turc. (11,3 %). The damage of bud of *A. monspessulanum* (19,3 %), *A. hippocastanum* (16,7 %), *S. torminalis* (17,3 %), *S. caucasica* (22,7 %) та *Rh. kerrioides* (30,0 %) exceed the analogue ones at *A. platanoides*. Insignificant damage of bud (1,33 %) were established at *S. japonicum* and *L. tulipifera* (pic. 2), while buds *Rh. kerrioides* (30 %) and *S. caucasica* (22,7 %) are mostly damaged. The latter suffers, in particular, in comparison with others mostly from the damage of middle part of shoot (through the bud) - 37,8 %. At the same time the bud *A. Platanoides* is damaged for 13,3 % (pic. 3).

Taking into account the research results, we can conclude that the apical part of the main quantity of exotic species is damaged most of all in comparison with native type, while the damage of bud and the middle part of shoot (through

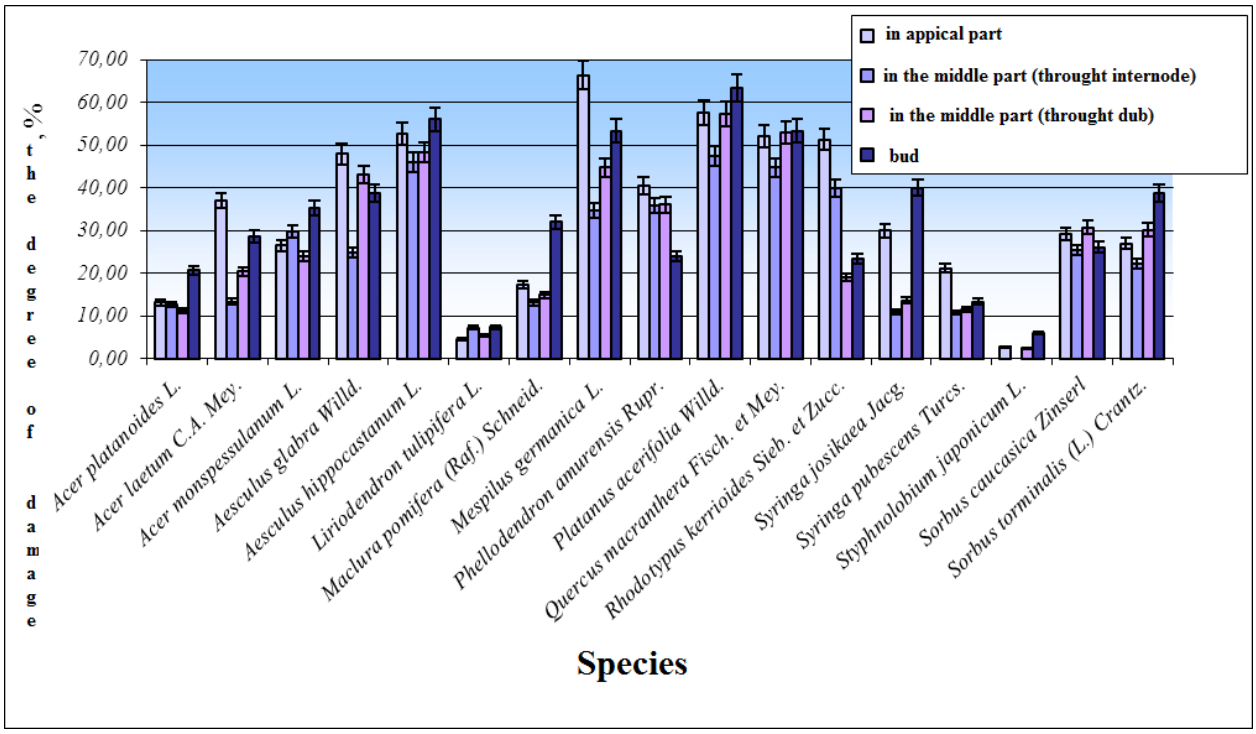
the bud) among the most researched species are not so significant than their analogues among *A. platanoides* L.



Pic. 2. A cut of a shoot through the bud *L. tulipifera* at temperature effect of -25° C

Pic. 3. A cut of shoot through the bud *A. platanoides* at temperature effect of -25° C

At temperature -30°C the damage degree of some shoot parts grow dramatically, if the changes are insignificant at *A. platanoides* L. Less shoot and bud damage was found among *S. Japonicum,* in particular in apical part 2,7 %, in middle part (through the internode) - 0,0 %, middle part (through the bud) – 2,3 %, the bud damage is 6,0 %. Minor shoot damage in middle part (both through internode and bud) was found at *L. tulipifera*. They are twice, and the bud three times less than at *A. Platanoides.* Shoots and buds of all other exotic species are more damaged than those ones of native species (pic.4). However, almost apical part of shoots of *M. germanica* and bud of *P. acerifolia* – 63,3 % underwent critical damage (66,3 %). In addition to this, the middle part of the shoots of latter (both through the internode and bud) was also damaged among researched species - 47,4 % and 57,3 % respectively.



Pic. 4. Damage degree of tissue of different shoot parts of exotic species at temperature -30°C

All shoot parts of *Rh. kerrioides* suffered from great damage, however, - bud suffered most of all (53,3 %). Insignificant (up to 30 %) damage of apical part of shoots were observed among the following species: *M. pomisera* – 17,1 %, *S. pubescens* (21,1 %), *A. monspessulanum* – 26,4 %, *S. torminalis* – 26,9 % and *S. caucasica* – 29,1 %, *S. josikaea* (29,9 %). Middle part (through the internode) of shoots of all exotic species is less damaged than the apical part, especially at *S. pubescens* – 10,7 %, *S. josikaea* – 10,9, *M. pomisera* – 13,1 %, *A. laetum* – 13,3 %, *S. torminalis* – 22,2 %, *A. glabra* – 24,7 %, *S. caucasica* – 25,4, *A. monspessulanum* – 29,7 %. The damage of the middle part (through the bud) of exotic species is less than 30% is observed among *S. pubescens* – 11,4 %, *S. josikaea* – 13,6, *M. pomifera* – 14,8, *A. monspessulanum* – 20,9 and *A. laetum* – 20,3 %. One should notice that the apical part of the latter is damaged for 37 %, the bud - 28,7 %, while at *A. Monspessulanum* 26,4% and 35,3 % respectively. Bud damage with 30 % was observed among *S. japonicum* (6,0 %), *L. tulipifera*

(7,33 %) and *S. pubescens* (13,3 %) *Ph. amurensis* (24,0 %), *S. caucasica* (26,0 %).

According to analysis of damage indicators all parts of shoots and buds at the temperature -30°C, shoots of most part of exotic species are damaged more significantly in comparison with habitat species. Though there are some exceptions. Meanwhile, there were no damages among the exotic species under research.

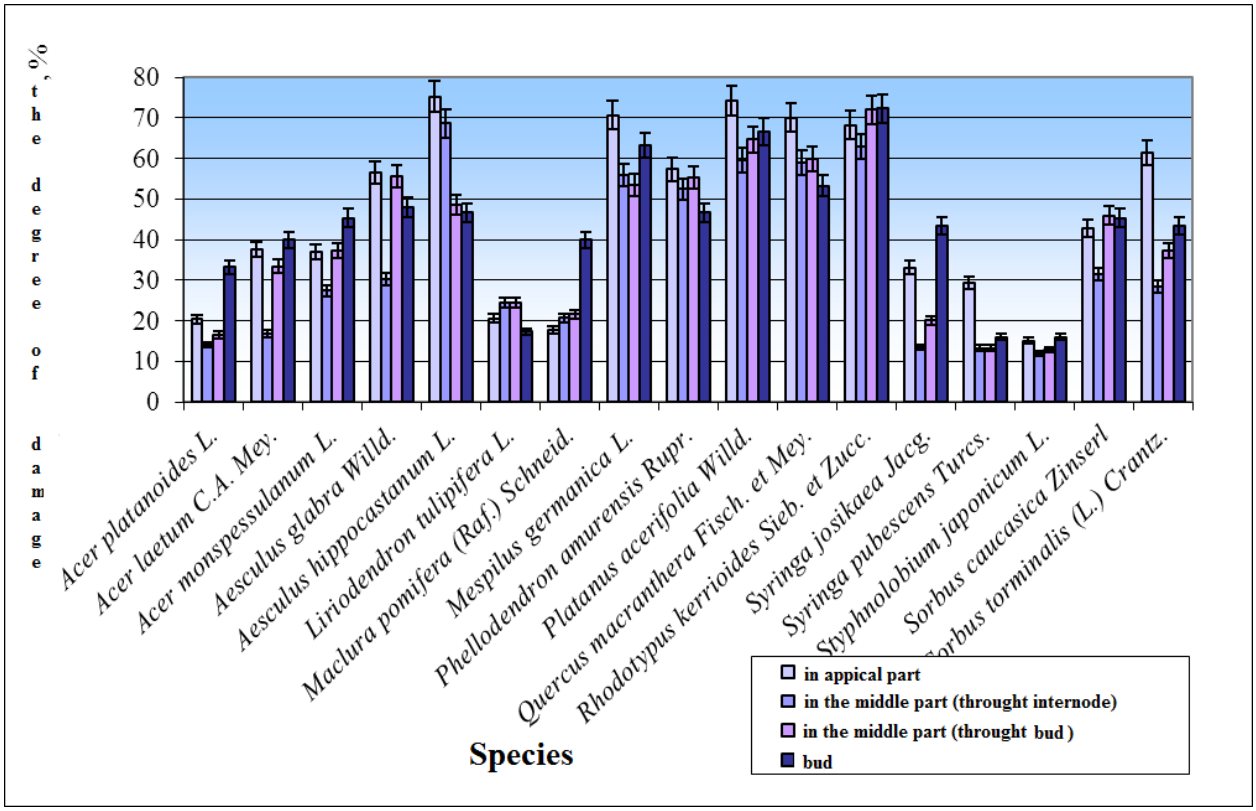
During the following research of potential frost hardiness of species in conditions of low temperatures to -35° C everything is changing drastically (pic.5). The damage of apical part of shoots *A. Platanoides* gains 20,4 % and they are close to damage *L. tulipifera* (20,7 %). Less damage, as in the previous case, was suffered by shoots *S. Japonicum* where their level fluctuates at different parts from 12,0 % to 15,1 %, with the biggest indicator at the bud - 16,0 %. At the same level the damage was found at a bud *S. Pubescens* with quite differential character of shoot damage in various parts – apical – (29,3 %) and middle (through the bud and the internode) - 13,3 %.

At the same time, similar damage degree of shoots both through the bud and through internode is observed only among mentioned species. What the damage of apical part of shoots of exotic species concerns, here *A. Hippocastanum* stands out. Its apical part of shoots (75,3 %) suffers from most damage. The apical parts of *P. acerifolia* (74,3 %), *M. germanica* (70,7 %) and *Q. macranthera* (70,0 %) suffered from critical damage. *Rh. kerrioides* was almost critical (68,3 %).

The damage of middle part (through internode) among any of researched species exceeds critical indicators, though shoots of *A. Hippocastanum* in this part the most vulnerable – 68,7 %.

Also one can observe significant damage in the part of shoots *Rh. kerrioides* (63,0 %). The following species suffered insignificant damage: *S. josikaea* (13,5 %) *A. laetum* (16,8 %), *M. pomifera* (20,8 %), *L. tulipifera* (24,4 %), *A. monspessulanum* (27,5 %), *S. torminalis* (28,5%), *A. glabra* (30,2 %) and *S. caucasica* (31,5 %). As for other species, the damage of their part of shoot is

much more significant and fluctuate from 52,5%-59,7%, especially at *Ph. amurensis* (52,5 %), *M. germanica* (56,0 %), *Q. macranthera* (59,0 %) та *P. acerifolia* (59,7 %).



Pic. 5. Damage degree of tissue of different part of shoots among exotic species at the temperature -35°C

Damage of shoots of *A. platanoides*, as among the majority of exotic species, has differential character. Especially the bud suffers most of all - 33,3 %, the middle part is less damaged (through the internode) - 14,1 %. Insignificant damage of all parts of shoots, except for above-mentioned, was found at *L. tulipifera* (20,7-24,4 %) and *M. pomifera* (17,9-21,6 %). However, the bud of latter is damaged for 40,0 %. The damage of bud *L. Tulipifera* is insignificant – 17,3 % (pic. 3.12) and this is twice less than those ones of native species.

According to the analysis of indicators damage in the middle part (through the bud), the damage of *Rh. Kerrioides* turned out to be greater - 72,0, shoots of *P. acerifolia* suffered from significant damage (64,7 %). Only *S. japonicum* (12,8 %), *S. pubescens* (13,3 %), *S. josikaea* (20,1 %), *M. pomifera* (21,6 %) and

L. tulipifera (24,4 %) suffered from tissue damage (up to 30%). *Rh. kerrioides* (72,3 %) suffered from the greatest bud damage. Therefore, taking into account the results of research of frost hardiness of exotic species at the temperature -35°C, one should pay attention to the species, certain parts of shoots of which suffer from great damage, namely - *Ae. hippocastanum* and *Rh. kerrioides*.

Taking into consideration the results of research and wide usage and unsatisfactory condition of the samples of *A. Hippocastanum* at the territory of MPLA CHADR, it is reasonable to fulfill the comparative analysis of damage indicators by the effect of low temperatures of its shoots and *A. Glabra* in order to identify the most perspective of them. In particular, the damage of shoots of *A. Glabra* at the temperature - 25,1°C (control) is insignificant and quite differential depending on the part of shoot. The lowest their indicator is in the middle part (through the internode) - 1,2 %, while *A. Hippocastanum* has 10,1 %, and in apical parts (where damage is more sufficient among both species) - 8,3 % i 24,7 % respectively. The bud turned out to be more damaged for 16,7 % in *A. hippocastanum*. In case temperature decrease to -30°C, difference between damage of different parts of shoots of species is decreasing. However, the damage degree of *A. Hippocastanum* exceeds sufficiently the analogue indicators at *A. glabra*. Temperature -35°C is critical for one-year shoots of *A. hippocastanum,*when the damage of tissue achieves 75,0 % in apical part at this indicator for *A. glabra* 56,5 %. The difference of damage degree of the bud is insignificant and comprises 48 % for *A. Glabra* and 50 % for *A. Hippocastanum.*

According to damage degree analysis of certain tissues of different parts of shoot, the most surprising as for temperatures is apical part, in which one can observe the damage of bark both at A. Glabra and A. Hippocastanum that in control comprise 6,0 % and 11,6 % respectively. Though its damage degree in middle part is sufficiently less – only 1,2 % and 6,6 % respectively. According to graphic data, the damage of other tissues in the middle part (through the internode) *A. Glabra* are absent, while *A. Hippocastanum* has for cambium 2,4 %, wood - 0,8 %, core– 0,3 %. Almost similar damage degree of tissue is observed in the

middle part (through the bud). The damage of bud *A. Glabra* at the temperature-30°C is 38,7 %, *A. Hippocastanum* has 50 %. Thus, temperature -30°C can be regarded as critical, while bud *A. Glabra* thus remains viable. Thus, hence we can make a conclusion that damage degree of tissues among all parts of one-year shoots *A. Glabra* with temperature effect that is much lower in comparison with *A. Hippocastanum* and it is an evidence of its best frost hardiness among others.

Conclusion

According to the results of frost penetration of shoots that was performed in laboratory, there are species among Eastern Asian floral region that are sufficiently high potential frost hardy (*S. japonicum*), those ones with average indicator (*A. laetum*, *Ph. amurensis*) and those ones that are not frost-resistant (*Rh. kerrioides*). Species that are naturally grow at the territory of Atlantic-Northern America region are frost resistant. The species that are spread only at the territory of Circumboreal floral region are potentially frost-hardy. In addition to this, one should mention *S. Torminalis*, the sample of which suffered from great damage in comparison with other representatives of the region. More vulnerable to low temperatures effect turned out to be the species natural habitat of which are situated in the bounds of two region - Circumboreal and Iranian-Turanian, and the representative from Mediterranean floral region and hybrid.

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МОРОЗОСТІЙКІСТЬ ІНТРОДУЦЕНТІВ ПАРКІВ-ПАМ'ЯТОК САДОВО-ПАРКОВОГО МИСТЕЦТВА В УМОВАХ ЦЕНТРАЛЬНОПРИДНІПРОВСЬКОЇ ВИСОЧИННОЇ ОБЛАСТІ

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Представлені результати порівняльного аналізу морозостійкості деревних інтродуцентів, зосереджених в насадженнях парків-пам'яток садово-паркового мистецтва на території Центральноприднiпровської височинної області, визначено найморозостійкіші.

Ключові слова: морозостійкість інтродуцентів, парки-пам'ятки садово-паркового мистецтва

МОРОЗОСТОЙКОСТЬ ИНТРОДУЦЕНТОВ ПАРКОВ-ПАМЯТНИКОВ САДОВО-ПАРКОВОГО ИСКУССТВА В УСЛОВИЯХ ЦЕНТРАЛЬНОПРИДНЕПРОВСКОЙ ВЫСОЧИННОЙ ОБЛАСТИ

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Представлены результаты сравнительного анализа морозостойкости древесных интродуцентов, сосредоточенных в насаждениях парков-памятников садово-паркового искусства на территории Центральноприднепровской высочинной области, определены самые морозостойкие.

Ключквые слова: морозостойкость интродуцентов, парки-памятники садово-паркового искусства