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The Results Of Introduction Of East Asian Origin Flowering Plants In The Southwest Of Central Russian Upland.

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ABSTRACT

The article is devoted to the study of the results of introduction of East Asian origin flowering plants, growing in the dendrological collection of Belgorod Botanical Garden. The most important ecological and biological characteristics of the plants were studied; the score of species was given based on the results of the research. The estimation of the growth and development nature of introduced species, according to their resistance to the complex of unfavorable factors, was carried out. The perspective species for use in the south-west of Central Russian Upland were pointed out. The ability of plants to individual dissemination in local conditions was researched. This will allow to use them successfully in variety types of planting.

Keywords: invasive plant, dendroflora, winter hardiness, drought hardiness, estimation of perspectivity, the geographical center of East Asia.

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INTRODUCTION

The important stage of preserving the genetic resources of introduced plants is a comprehensive study of their ecological and biological features in culture conditions. Botanical gardens play the leading role in expanding of areals by species of plants and enrichment of phytocenosis cultures by new valuable plants.

The analysis of geographical origin of the wood invasive plants shows, that the most valuable and widely grown species comes from the East Asian introduction center, which includes the largest number of regions: the Russian Far East up to Kamchatka, China, Korea and Japan.

The purpose of the research is to identify perspective species of woody plants of the East Asian origin for enrichment of the south-west of Central Russian Upland dendroflora. To achieve this goal, the main objectives are the following: to study the seasonal rhythm of growth and development of plants and identification of promising woody plants on the basis of the integrated scale.

METHODS

The objects of the research are woody plants of East Asian origin, cultivated in the arboretum since 2001. The names of taxa in the bloodline and partially genus are presented according to A.L. Takhtadzhyan [1], generic and specific names are given by S.K. Cherepanov [2], in some cases, the names are used from different dendrologic reports [3, 4].

Life forms of plants are determined by the system of I.G. Serebryakov [5]. The groups of growth are determined by the method of S.Y. Sokolov [6], where all invasive plants are divided into several groups, depending on their height.

Winter hardiness, drought hardiness, the resistance to diseases and pests, the seed productivity of invasive plants were estimated to determine the rate of adaptation. [7, 8].

The degree of species adaptation was determined as the ratio of actual scores to the sum of the maximum possible scores. This ratio is called the adjustment factor and is expressed by the formula: KA = S1 / S* x 100, where: KA - adaptation factor; S1 - the sum of the actual score; S * - the amount of scores of completely adapted plant.

MAIN PART

The most important characteristics of species, that provide adaptation to the new conditions and suitability for their use, are the following: winter hardiness, drought hardiness, resistance to diseases and pests, reproduction, capacity for independent living and other useful qualities (aesthetic qualities, eatability, medicinal qualities, etc.) [9-11]. The studies of the plants introduction of different origin are necessary to identify common patterns of species domestication in different climatic conditions [12-13]. In this regard, we carried out the study of the state and germinating power of 76 plants species of East Asian origin, belonging to 25 bloodlines in the conditions of Belgorod Botanical Garden. Based on the conducted researches, the invasive plants were given the score of the main characteristics, according to which the studied species were divided into the groups of prospects (see Table.).

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Table: Prospective Assessment of Plants

Item number	Life form	Plants, origin (areal)	Winter hardiness, score	Drought hardiness, score	Diseases and pests resistance, score	Seed reproduction	The rate of adaptation %	The group of prospect	The ability for natural dissemination and survival
Caprifoliaceae Vent.									
1	Sh	*Lonicera edulis* Turcz. Ex Freyn., Eastern Siberia, the Far East	5	4	5	4	90	1	-"-
2	Sh	*Lonicera alpigena* L., the Far East	5	4	5	4	90	1	-"-
3	Sh	*Weigela florida (*Bunge) DC., the Far East, China	5	4	5	4	90	1	-"-
4	Sh	*Weigela floribunda (*Sieb. & Zuss.) C. Koch., the Far East, China	5	4	5	4	90	1	-"-
5	Sh	*Weigela praecox* (Lemoine) Bailey, the Far East	5	3	5	4	85	1	-"-
Hydrangeaceae Dumort									
6	Sh	*Hydrangea bretscneideri* Dipp., China	5	3	5	1	65	3	-"-
7	Sh	*Hydrangea paniculata* Sieb., Japan, China	5	3	5	4	85	1	-"-
8	Sh	*Deutzia scabra* Thunb., China	5	4	5	4	90	1	-"-
9	Sh	*Deutzia schneideriana* Rehd., the Far East	5	4	5	4	90	1	-"-
10	Sh	*Deutzia vilmoreana* Lemoine., China	5	4	5	4	90	1	-"-
11	Sh	*Deutzia amurensis (Rgl.) Airy-Shaw.,* the Far East	5	4	5	4	90	1	-"-
Buddleaiaceae Wilhelm.									
12	Sh	*Buddlea davidii* Franch., China, Japan	4	5	5	4	90	1	-"-
Araliaceae Juss.									
13	T	*Aralia mandshurica* Rupr. et. Maxim., Primorye, China	5	4	5	5	95	1	Pe
14	Sh	*Eleutherococcus senticosus* (Rupr.& Maxim.) Maxim., Eastern Siberia, the Far East, China	5	4	5	4	90	1	Pe
Celastraceae Lindl.									
15	T	*Euonymus bungeanus* Maxim. the Far East, China	5	4	4	4	85	1	Pe
16	Sh	*Euonymus alatus* (Thunb.) Sieb., China	5	4	5	4	90	1	Pe
17	L	*Celastrus orbiculata* Thunb. the Far East	5	4	5	4	90	1	Pe
Elaeagnaceae Lindl									
18	Sh	*Elaegnus multiflora* Thunb., Japan	5	5	5	4	95	1	Pe
19	Sh	*Elaegnus umbellata* Thunb., Japan, China	5	5	4	4	90	1	Pe

Cornaceae Link.									
20	Sh	*Cornus officinalis* Sieb. & Zucc., Japan	4	4	5	4	85	1	-"-
Malvaceae Juss.									
21	Sh	*Hibiscus syriacus* L., China, Central Asia and Asia Minor	2	5	5	4	80	2	-"-
Fabaceae Lindl.									
22	Sh	*Lespedeza bicolor* Turz., Eastern Siberia, the Far East	4	4	5	4	85	1	Pe
Moraceae Link.									
23	T	*Morus alba* L., China	5	5	5	4	95	1	Pe
Rosaceae Juss.									
24	Sh	*Louiseania triloba* (Lindl.) Pachom., China	5	4	5	3	90	1	-"-
25	Sh	*Kerria japonica* (L.) DC., Japan, China	4	3	5	4	80	2	-"-
26	Sh	*Chaenomeles japonica* (Thunb.) Lindl., Japan	5	4	5	5	95	1	Pe
27	Sh	*Chaenomeles maulei* (Mast.) C.K., Schneid. Japan	5	4	5	5	95	1	Pe
28	Sh	*Stephanandra* incisa Zab., the Far East	4	4	5	3	70	3	-"-
29	T	*Micromeles alnifolia* (Siebold et Zucc.) Koehne, the Far East	4	4	3	3	60	3	-"-
30	T	*Crataegus chlorocarpa* Maxim., the Far East	5	4	4	4	85	1	-"-
31	T	*Crataegus maximowiczii* Schneid., the Far East	5	4	4	3	80	2	-"-
32	Sh	*Rosa multiflora* Thunb., the Far East	5	4	5	4	90	1	Pe
33	Sh	*Rosa rugosa* Thunb., the Far East	5	4	5	4	90	1	Pe
34	T	*Sorbus pahuashanensis* (Hence.) Hedl., China	5	4	5	2	80	2	Pe
35	Sh	*Sorbaria sorbifolia* (L.) A. Br., the Far East	5	4	5	4	90	1	E
36	Sh	*Physocarpus amurensis* Maxim., the Far East	5	4	5	4	90	1	Pe
37	Sh	*Spiraea x bumalda* Burv. *(S. japonica x S. albiflora),* Japan	5	4	5	4	90	1	Pe
38	Sh	*Spiraea japonica* L., Japan	5	4	5	4	90	1	Pe
39	Sh	*Spiraea vanhouttii* (Brott.) Zbl., China	5	5	5	4	95	1	Pe
40	Sh	*Spiraea betulifolia* Pall., the Far East	5	4	5	4	90	1	Pe
41	Sh	*Spiraea nipponica* Maxim., Japan	5	4	5	4	9	1	Pe
42	Sh	*Spiraea latifolia* (Ait.) Borkh., East Asia	5	4	5	4	90	1	Pe
43	Sh	*Spiraea albiflora* (Migg.) Zbl., East Asia	5	4	5	4	90	1	Pe
44	T	*Armeniaca mandshurica* (Maxim.) Skvorts., the Far East	5	5	4	5	95	1	Pe
45	T	*Cerasus maximowiczii* (Rupr.) Kom., the Far East	5	4	5	4	90	1	Pe
46	T	*Cerasus tomentosa* (Thunb.) Wall., China	4	5	5	5	95	1	Pe
47	T	*Pyrus ussuriensis* Maxim., the Far East	5	4	3	2	70	3	-"-
48	T	*Malus baccata* (L.) Borkh., Siberia, the Far East	5	4	3	4	80	2	-"-
49	T	*Malus prunifolia* (Willd.) Borkh., the Far East, China	5	4	4	3	80	2	Pe
50	T	*Malus x cerasifera Spach. (M. prunifolia x M. baccata),* the Far East	5	4	4	3	80	2	Pe
Paeoniaceae Rudolphi									
51	Sh	*Paeonia suffruticosa* Andr., China	5	4	5	4	90	1	-"-
52	Sh	*Paeonia delavayi* Franch., China	5	4	5	4	90	1	-"-
Rutaceae Juss.									
53	T	*Phellodendron amurense* Rupr., Primorye	5	4	5	5	95	1	Pe
Salicaceae Mirb.									

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54	T	*Salix matsndana* Koidz., Mongolia, China	4	3	5	4	80	2	-"-
55	T	*Populus simonii* Carr., China	4	4	5	5	90	1	-"-
56	T	*Populus maximowiczii* A. Henri, the Far East, China	5	4	5	5	95	1	-"-
Aceraceae Lindl.									
57	T	*Acer ginnala* Maxim., the Far East	5	4	5	5	95	1	Pe
Berberidaceae Torr. Et Gray									
58	Sh	*Berberis coreana* Palib., Korea	5	4	5	4	90	1	Pe
59	Sh	*Berberis thunbergii* DC., Japan, Korea	5	4	5	4	90	1	Pe
Juglandaceae Lindl									
60	T	*Juglans ailantifolia var. Cordiformis* (Maxim.) Rehd., China	4	4	5	3	80	2	-"-
61	T	*Juglans manshurica* Maxim., the Far East	5	5	5	4	95	1	Pe
Ulmaceae Mirb.									
62	T	*Ulmus parvifolia* Jacq., the Far East, Central Asia, China	5	5	5	5	100	1	E
Cercidiphyllaceae Engl.									
63	T	*Cercidiphyllum japonicum* Sib. & Zucc., the Far East	4	4	5	3	80	2	-"-
Oleaceae Lindl.									
64	T	*Syringa amurensis* Rupr., the Far East	5	4	5	4	90	1	Pe
65	Sh	*Syringa velutina* Kom., China	5	4	5	4	90	1	Pe
66	Sh	*Syringa villosa* Vahl., China	5	4	5	4	90	1	Pe
67	Sh	*Syringa wolfii* Schneid., the Far East, China	5	4	5	4	90	1	Pe
68	Sh	*Syringa x prestoniae* Mc. Kelvey. *(S. villosa x S. reflexa),* East Asia	5	4	5	4	90	1	Pe
69	Sh	*Forsythiae suspensa* (Thunb.) Vahl., Korea, Japan, China	5	4	5	4	90	1	Pe
70	Sh	*Forsythiae ovata* Nakai., Korea, Japan, China	4	4	5	4	85	1	Pe
Vitaceae Lindl.									
71	L	*Vitis amurensis* Rupr., the Far East	5	4	5	5	95	1	Pe
72	L	*Ampelopsis brevipedunculata (*Maxim.) Trautv., the Far East	5	4	5	4	90	1	Pe
Solanaceae Juss.									
73	L	*Lycium chinensis* Mill., China	3	5	5	4	85	1	Pe
Bignoniaceae Juss.									
74	T	*Catalpa ovata* G. Don., China	4	4	4	4	80	2	-"-
Magnoliaceae Juss.									
75	T	*Magnolia kobus* DC., China, Primorye	4	4	5	1	70	3	-"-
Simaroubaceae D. C.									
76	T	*Ailanthus altissima* (Mill.), Swingle. China	3-4	4-5	5	3	85	2	-"-

Note: T – trees, Sh – shrubs, L – lianas, E – ergaziofit, Pe – potential ergaziofit, -"- – species incapable to autonomous dissemination.

According to the low temperatures, all studied species of plants are high winter-hardy and winter-hardy. However, in some species, such as *Deutzia schneideriana, Eleagnus umbellata, Physocarpus amurensis* and others, during the first 2-3 years after planting, it was observed the frosting of shoots, up to the height of the snow cover, following by rapid recovery. With age, the freezing of these plants have ceased. During the years with long cold winter period, it was indicated freezing of the tops of the annual shoots in the genera with weak suberification of shoots (*Cornus, Kerria, Magnolia*) and in plants with long, more than 100 days, growth of shoots (*Vitis, Kerria, Stephanandra*). Such plants as *Ailanthus altissima*, *Lycium chinensis* were medium winter-hardy (3 scores). These are the plants with a late end of vegetation development and with the continued growth of shoots. With age, the winter hardiness of these plants has increased, and during the

generative period, there is the phase of flowering and fruiting each year. Among all the observed plants, *Hibiscus syriacus* has low winter hardiness (2 scores), which annually frosting to the surface of the soil. With age, the winter hardiness of this specie has not increased. There is a constant risk of growing this specie into collections, so this plant needs annual winter covering and more careful handling after overwintering.

Annually held phenological observations identified the belonging of most plants of East Asian origin, to a series of phenological variations: the plants with early start and early end of vegetation development, the plants with late start and early end of vegetation development. Their shoots to the end of the growing season completely lignified, that has a significant impact on the winter hardiness of the plants.

Most of the East Asian origin plants are high drought-resistant and drought-resistant. During the dry season, the growth of these plants' shoots occurred without changes, the state of vegetative and generative organs was satisfactory. In some species (*Ailanthus altissima, Juglans ailantifolia, Malus baccata, Malus prunifolia*) the premature defoliation, the reducing of shoots growth duration and short-term loss of turgor were observed. Some species of such bloodlines as Hydrangeaceae*, Salicaceae* and *Caprifoliaceae* are medium drought-resistant. During the dry spring and summer periods, they had wilting the tops of separate branches, weak blossoming, the loss of turgor, premature defoliation, stunted growth and development. These species require additional handling, i.e. watering; after that, they are fully recovered and continued to vegetate in normal rhythm.

Diseases and pests limit the possibility of plants introduction in the same degree as abiotic factors. The resistance to the pests and diseases is the higher, the far taxonomically and geographically stands invasive plant in relation to the plants of local flora. The discrepancy between the cycle of local pests development with phenological rhythm of invasive plants or absence of specific pathogenic organisms, contributed to the fact, that almost all the plants of the East Asian origin are resistant to the pests and diseases. The exception is the *Rosaceae* plants. They had unessential damages, causing by leaf-eating and sucking pests. Along with local species of Euonymus, it were noted the damages, caused by allied moth, in *Euonymus bungeanus.*

The ability of invasive plant to the production of high-grade seeds in new environment is one of the most important indicators of its adaptation. 64 species (84.2%) of all researched species regularly flower and fruit. Most of these plants belong to mesoxerophytic environmental group - dry periods, that are typical for the Belgorod region, do not have a significant impact on them. The significant impact of the dry summer period on the abundance of flowering and fruiting have been noticed in such plants as *Catalpa ovata*, *Lycium chinensis*, *Ampelopsis brevipedunculata* and some species of the genus *Spiraea*. Poor flowering and fruiting (3 scores) was observed in *Malus prunifolia, Ailanthus altissima, Cercidiphyllum japonicum*, and others. According to our observations, this group includes plants, growing in conditions with shallow groundwater and growing on soils with peat predominance or having light composition, but differing by fertility. In our conditions, these plants suffer from lack of moisture. This group includes sterile form *Louiseania triloba* that can reproduce vegetatively. Two species of *Rosaceae* plants have two scores. *Sorbus pahuashanensis* had weak flowering, the seeds were not rising. *Pyrus ussuriensis* had poor blooming and fruiting. It is in weakened state due to fungal disease.

Natural seeding, shoot-forming capacity and the ability to independent dissemination in local conditions were taken into account in order to search and attract the invasive plants more efficiently, to prevent possible negative consequences of their introduction and use in natural plant communities.

Among 76 monitored species, there are 2 species (*Ulmus parvifolia, Sorbaria sorbifolia*) belonging to ergaziofits. These species long ago entered the local natural communities of the region and actively multiplied on the territory of botanical garden. They can even displace the local representatives of dendroflora and gradually move into the category of weeds.

42 plants species were referred by us to potential ergaziofits. At the moment, they occur infrequently in the region, though they have all complex of characteristics, which provide them independent dissemination within the area of introduction. The rest of the studied species are able to exist only in the collections of botanical garden, or within private gardens. The example is the plants of tropical origin: *Ailanthus altissima, Lycium chinensis, Hibiscus syriacus* and others.

DEDUCTIONS

Based on the indicators analysis of the plants germinating power and the amount of scores we assessed the prospects of 76 studied plants species. 3 groups of plants were distinguished according to perspectivity. The main branch of economic activity, where they can find application, is gardening, and partly industrial and amateur gardening.

The group of prospective for the region species includes 57 items. They are used in decorative cultivation (*Syringa x prestoniae, Forsythiae ovata, Syringa wolfii* et al.), in the fruit horticulture (*Vitis amurensis, Juglans manshurica, Armeniaca mandshurica* et al.), in forestry and protective afforestation (*Acer ginnala, Populus maximowiczii, Phellodendron amurense*, etc.).

The group of successful invasive plants includes 12 species. The plants of this group are quite suitable for the use in landscaping, due to their successfully vegetating and quickly recovering after severe winters.

The group of potentially successful invasive plants includes 7 species. The plants of this group are suitable for use in landscaping, but require more care handling.

CONCLUSIONS

East Asian Dendrological Centre is the rich introduction source of new and prospective species in the south-west of Central Russian Upland.

Most of the studied plants are high winter-hardy and winter-hardy. Observations have shown, that many plants species at the young age suffered from damages during winter period, but with age the freezing has stopped. So, the age factor plays significant role for winter hardiness of invasive plants. The different terms of shoots ripening have great impact on winter hardiness. The species with late start and late end of vegetation, with long-term growing and terms of shoots ripening have the lowest winter hardiness. The invasive plants from China, having the long term of shoots lignification, more than other suffer from low temperatures. It is also noted, that the plants damages during the winter period are connected not only with low temperatures, but also with a whole set of related factors. In our region, these important for introduced species climatic factors include the following: the instability of snow covering or its fully absence; sharp temperature swings - alternating of cold periods with thaws; easterly winds, cold and dry in winter.

East Asian plants are resistant to the pests and diseases. The indicator of plants resistance to the pests and diseases is necessary in the process of introducing them to the culture, for the timely application of needed pesticides and for the search of exotic woody species resistant to pests and diseases.

The success of the introduction depends on the ability of plants to produce full seeds. In the process of seed reproduction, one can succeed when introduction into the culture of those species, that are considered to be unpromising in our region.

Such indicator as the plants ability for autonomous dissemination in the conditions of the region is particularly important and necessary when used in protective afforestation and creating forest plantations. The group of plants, belonging to ergaziofits, requires increasing control while using in green building. The greatest numbers of East Asian origin species in the collection of Belgorod botanical garden are potential ergaziofits, which can be widely used in various types of plants in the future.

Most of the studied species are promising for use in various fields of economic activity. Comprehensive development of East Asian dendroflora significantly enriches the range of trees species, used in various branches of economy in the south-west of Central Russian Upland.

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