Perculiarities of introduction of Araliaceae Juss. in botanical gardens (Kyiv, Ukraine)

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The results of physiological, morphological, anatomical peculiarities of introduced plants of Araliaceae Juss. have been given. Study of seasonal growth and development peculiarities of Araliaceae Juss. showed that most of these plants were introduced successfully but the process was complicated by climatic conditions of the area in city Kiev. According to a comprehensive assessment a large number of studied species were highly evaluated for decorative effect. Introduced species of family Araliaceae Juss. are characterized by high-level adaptation to local soil and climatic conditions in Botanical gardens of Kiev. The vast majority of them bloom but not all can form seeds. Thus, among the introduced plants only five representatives of genus Acanthopanax – Acanthopanax lasiogyne, Acanthopanax divericatus, Acanthopanax sieboldianus, Acanthopanax trifolius and Acanthopanax wardii have high level of adaptation. To determine the prospect of cultivating research species we assessed the degree of winter resistance by the 5-point M. K. Vechova scale on the basis of visual observations in conditions of the open ground. The level of adaptation of plants was evaluated in the city Kyiv using the estimation scale measured in points and in percentages. Results of research showed that the species have a high resistance to the effects of adverse factors. All types of this family are promising for introduction into culture and can be widely used in various branches of the national economy. A comprehensive assessment of the decorative effect of ornamental plant species was carried out by the O. G. Horoshyy and O. V. Horoshyy scales, according to which the decorative effect of the vast majority of studied species was highly appreciated. The results of our study shows that the introduced species of Araliaceae Juss. have a good prospect for further their use in ornamental gardening, urban greening and landscape design in private territories of citizens.

Keywords: adaptive index; adaptation success; decorative effect; reproductive ability; winter resistance

Introduction

Recently technogenic impact and climate change affect the state of living organisms: plants (Lykholat & Hryhoryuk, 2005; Khromyk et al., 2018; Priede et al., 2017), animals and people (Peregrym et al., 2014). In these conditions, introduction of introduced species into landscaping enhances the range of local spectrum of species having transformative environment properties (Alexeyeva et al., 2016).

In Ukraine, as well as throughout the world centers of plant protection and introduction are botanical gardens constantly increasing their diversity (Afanasyeva et al., 1997; Kilpatrick, 2014; Shalimov, 2008). Despite such a positive dynamics in the increased species diversity, it should be noted the introduction of rare plant species, as well as the introduction into the culture of any other group of plants, always occurs with losses associated with different objective and subjective reasons (Fedorov, 1982; Frei et al., 2014; Fujimaki et al., 2012; Heylighen, 2007), which is reflected on their external functional state (Karapetyan, Bukhov, 1986; Vorobyev, 1986; Endress, 2002).
Therefore, during the introduction process for the further effective development of the collection of rare and introduced species of plants, more attention should be paid to the biomorphological, geographic and genetic analysis of the studied species currently represented in collections of botanical gardens, in order to identify the most promising groups for further active use in landscaping on the basis of their features (Sokolov, 1957; Peregrym et al., 2014; Umair et al., 2017; Zaman et al., 2018; Zhang et al., 2018).

A large number of species originating from the Far East introduced in Ukraine. This is due to the fact that most of them have medicinal traits. The attention to oriental medicine causes by constant interest in the study of characteristics and therapeutic properties of these plants.

From this perspective, representatives of Araliaceae Juss. are of considerable interest (Eyde, Tseng, 1971; Davydov, Krikorian, 2000; Shang, Lowry, 2007), so the purpose of our research was the study of their introduction process in Kyiv’ botanical gardens.

In the changing climate of Kiev, there are trends that suggest that over the past 20 years the average temperature in January and February has increased by almost 2.5 degrees. On a global scale, the number of cold days and nights has decreased and the number of warm days and nights has increased.

Winter period characterizes by alternation of frost with thaws. In average during the winter there are 8–10 thaws lasting from 5 to 30 days. Sometimes they can cause premature vegetation of plants. The duration of growing season is 190–205 days. The average annual amount of precipitation is 550–700 mm, the evaporation does not exceed 400–450 mm.

Materials and methods

Investigated species grow in collecting plantations within the city of Kyiv. Research area includes Botanical Gardens of the city – M. M. Gryshko National Botanical Garden of National Academy of Science of Ukraine (M. M. Gryshko NBG), A.V. Fomin Botanical Garden of Kyiv National T. Shevchenko University (A.V. Fomin BG), Botanical Garden of National University of Life and Environmental Sciences of Ukraine (BG of NULES) (Fig. 1).

The climate of Kiev is moderately continental. The average annual temperature of ground air is 7.3 °C with an age range of 5.1 to 9.7 °C. The average minimum air temperature reaches -3.6 °C and the absolute is 32.2 °C; average maximum +11.6 °C, absolute +39.4 °C. The sum of the average daily air temperatures higher than + 5 °C and equals 3020 °C, above +10 °C and equals 2695 °C. The meteorological period of vegetation continues average 207 days (Fig. 2).

The data of the average monthly temperature was used from the web-site of Central Geophysical Observatory of B. I. Sreznevsky [http://www.cgo.kiev.ua/]. The change in the minimum average annual temperature prevails over the maximum.

The average rainfall is 655.3 mm/year with fluctuations ranging from 594.7 to 732.4 mm/year. Considering on difficult complex of terrain and significant general slope of the territory the precipitation for plants is ineffective. In average, there are about 100 days with snow cover in height from 10 to 30 cm (max. 75 cm) in Kiev. During long thaws the snow cover disappears. It should be noted, that in some years there are significant fluctuations in the distribution of precipitation in months and in their total amount for the year.

The main soil-forming material is loess which locates on a depth of 130–170 cm. The mechanical composition is medium loam. The loess is pale yellow in color, loamy, well sorted.
class of rockiness with developed porosity and lack of lamination. Carbonation is a characteristic feature of loess. Podzolized chernozem was formed on the base of loess.

In the stand of trees dominate such species as European hornbeams (*Carpinus betulus* L.) and English oak (*Quercus robur* L.). Grow such species as English field maple (*Acer campestre* L.) and Norway maple (*Acer platanoides* L.), small-leaved lime (*Tilia cordata* Mill) and European ash (*Fraxinus excelsior* L.). On the territory of botanical gardens growth old-aged oaks over 200 years old.

In the grass cover in the summer dominant herbaceous plant is *Impatiens parviflora* DC. Among other herbaceous species prevail *Carex capillaris* L., *Aegopodium podagraria* L., *Asarum europaeum* L., *Galeobdolon luteum* Huds., *Stellaria holostea* L., *Viola odorata* L., *Polygonatum multiflorum* (L.) All., *Galium odoratum* (L.) Scop.

In spring there are several types of ephemerals – plants that vegetate, bloom and yield only in the spring months and later dry up. They represented by *Anemone ranunculoides* L., *Ficaria verna* L., *Corydalis cava* (L.) Schweigg. & Körte., *C. solida* (L.) Clairv., *C. intermedia* (L.) Merat, *Gagea lutea* (L.) Ker-Gawl. and *G. minima* (L.) Ker Gawl., *Cardamine quinquefolia* (M.Bieb.) Schmalh., *Dentaria bulbifera* L. and *Scilla bifolia* L.

Plant observations were conducted on the territory of Botanical gardens of Kiev from August 2011 to September 2014. The age of trees was determined according to the materials of the last inventory. Height was set by using of the altimeter. Decorative qualities of species were estimated by 5-point scale of O. A. Kalinichenko (Table 1).

Comprehensive evaluation of decorative effect of decorative species of plants was conducted according to the scale of O. G. Horoshyh and O. V. Horoshyh (Kohno, Kurdiuk, 1994) (Table 2).

For determining the prospect of cultivating researched species we assessed the degree of resistance to winter conditions by 5 point scale N. K. Vehov (O. O. Kalinichenko, 1991) on the basis of visual observations in open ground (Table 3).

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**Table 1**

| Points | Decorative effect | Features |
|--------|-------------------|----------|
| 1      | Negative          | External appearance of plants reduces their overall decorative effect. |
| 2      | Zero              | Decorative qualities are imperceptible, plants have not expressiveness on the general background of plantings. |
| 3      | Inconspicuous     | Decorative qualities are noticeable, but indistinct and do not increase the decorative effect of plants. |
| 4      | Sufficient        | Decorative qualities are distinct, plants how up well on the general background of plantings. |
| 0      | High              | Decorative qualities give the plants a great attractiveness, causing an observer a great emotional feeling, admiration. |

**Table 2**

| Points | Decorative effect |
|--------|-------------------|
| To 14  | Low               |
| 15–28  | Medium            |
| 29–42  | High              |

Scale for assessing decorative attributes for O. G. Good and O. V. Good ones.

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Fig. 1. The climate of Kiev
Table 3
Scale for assessing of winter-resistance

| Points | Visual characteristics                                      |
|--------|-----------------------------------------------------------|
| 0      | complete freezing and destruction of plants              |
| 1      | terminal leader is completely damaged, but the plant lives and continues to grow from the lateral branches or can renewed from sprouts |
| 2      | half of length of the terminal leader is damaged          |
| 3      | the damage does not cover more than a quarter (1/4) of length of the terminal leader |
| 4      | no damage of the terminal leader, a new sprout develops from the apical bud |

The degree of drought resistance was determined by the 6-point scale of S. S. Pyatnitskiy (Kolesnichenko et al., 2010) (Table 4).

Table 4
Scale for assessing of drought-resistance

| Points | Visual characteristics                                      |
|--------|-----------------------------------------------------------|
| 0      | Plant dies under drought                                  |
| 1      | Leaves dropped off and dry off on the shoots              |
| 2      | More than half of leaves on plant and part of shoots dry off |
| 3      | Less than half of the leaves dry off                      |
| 4      | In the afternoon the leaves lose turgor, but after night it is restored |
| 5      | Plant does not suffer from drought                        |

Adaptation success researched species was determined by methodology of O. O. Kalinichenko which took into account reproductive capacity, winter and drought tolerance. The level of adaptation was established by score scale in points and percentages (%) (Table 5).

Table 5
Scale for assessing of adaptation success of species (Adaptive index, O.O. Kalinichenko, 1991)

| Level of adaptation, points | Adaptive rate amplitude,% |
|----------------------------|---------------------------|
| Not adapted (0)            | 0                         |
| Low (I)                    | 1–25                      |
| Medium (II)                | 26–50                     |
| Good (III)                 | 51–75                     |
| High (IV)                  | 76–100                    |

Results and discussion

Representatives of family Araliaceae Juss. are shrubs, trees and vines. They attract attention to flowers during the flowering period, the shape and color of leaves. Assessment of the decorative nature of the studied species, presented in Table 6.

During the visual assessment of the decorative items we took into account the architectonics of the body, wreaths, leaves, flowers and fruits. The results of the assessment of the decorative effect of Araliaceae Juss tree species on the basis of visual observations are given in Table 7.

During the observations of Araliaceae Juss. representatives in the beginning of vegetation we found damages from frost on branches of some species – Aralia mandshurica on the territory of the BG of NULES and on the territory of the O. V. Fomin BG (Fig. 2, 3). At the same time 3 affected shoots were detected in one plant. We can conclude that degree of winter resistance of these species according to the 5-point scale M. K. Velova is 3 points.

Another case of branch frost-damage was fixed in Eleutherococcus senticosus on the territory of the M. M. Gryshko NBG (Fig. 4).

The results of the studies indicate that Aralia mandshurica and Eleutherococcus senticosus more successful adapted under conditions of the National Botanical Garden of the M. M. Gryshko NBG with other species (80 %). However, plants of Hedera helix adapted weakly and the adaptive index is only 20 % (Table 9). In general, this specie is characterized by a low level of adaptation on the territory of Kiev – does not bloom and therefore does not form fruit (not capable to generative reproduction).
Table 8
Characteristic of state of tree species of Araliaceae Juss. growing on the territory of M.M. Gryshko NBG

| Tree specie                   | Quantity, pcs. | Age, years | Winter-resistance, points | Drought-resistance, points | Reproductive ability, points | Adaptive index, % and points |
|-------------------------------|----------------|------------|---------------------------|----------------------------|------------------------------|-------------------------------|
| Acanthopanax lasiogyne        | 1              | 60         | 4                         | 4                          | 5                            | 80, IV                        |
| Acanthopanax sessiliflorum    | 42             | 63         | 4                         | 5                          | 3                            | 60, IV                        |
| Aralia cordata                | 30             | 48         | 3                         | 4                          | 3                            | 36, II                        |
| Eleutherococcus senticosus    | 17             | 59         | 4                         | 5                          | 4                            | 80, III                       |
| Kalopanax septemlobus         | 2              | 64         | 4                         | 4                          | 4                            | 64, III                       |
| Oplopanax elatus              | 2              | 60         | 3                         | 4                          | 4                            | 48, II                        |
| Panax ginseng                 | 5              | 64         | 5                         | 3                          | 3                            | 45, II                        |
On the territory of the O. V. Fomin BG the largest variety of representatives are plants of genus Acanthopanax that characterized by a high level of adaptation (Table 10). As in the previous cases plants of genus Hedera are low-adapted.

Table 10
Characteristic of state of tree species of Araliaceae Juss. growing on the territory of O. V. Fomin BG

| Species                      | Quantity, pcs | Age, years | Height, m | Winter-resistance, points | Drought-resistance, points | Reproductive ability, points | Adaptive index, % and points |
|------------------------------|---------------|------------|-----------|---------------------------|---------------------------|-------------------------------|-------------------------------|
| Acanthopanax divaricatus     | 1             | 44         | 1,5       | 4                         | 5                         | 4                            | 80, IV                        |
| Acanthopanax sessiliflorum   | 1             | 74         | 3         | 4                         | 5                         | 3                            | 60, III                       |
| Acanthopanax sieboldianus    | 1             | 57         | 1,4       | 4                         | 5                         | 4                            | 80, IV                        |
| Acanthopanax trifoliatus     | 2             | 44         | 1,6       | 4                         | 4                         | 4                            | 60, IV                        |
| Acanthopanax wardii          | 1             | 38         | 1,8       | 4                         | 4                         | 4                            | 64, IV                        |
| Eleutherococcus senticosus   | 1             | 46         | 2,4       | 4                         | 5                         | 4                            | 80, IV                        |
| Hedera helix                 | 2             | 42         | x         | 4                         | 5                         | 1                            | 20, I                         |
| Hedera clychica              | 1             | 42         | x         | 4                         | 4                         | 2                            | 32, II                        |

Thus, among the introduced plants only five representatives of genus Acanthopanax – Acanthopanax lasiogyne, Acanthopanax divaricatus, Acanthopanax sieboldianus, Acanthopanax trifoliatus and Acanthopanax wardii, have high level of adaptation. From the other species only Aralia mandshurica has reached a high level of adaptation (Fig. 5).

Fig 5. Comparative assessment of the level of adaptation of species of Araliaceae Juss. on the territory of Botanical gardens of Kiev

Conclusions

According to a comprehensive assessment a large number of studied species were highly evaluated for decorative effect. Thus, introduced species Araliaceae Juss. have good perspective for further usage in ornamental gardening, landscaping of urban areas and private territories. Introduced species of family Araliaceae Juss. in Botanical gardens of Kiev characterized by high-level adaptation to local soil and climatic conditions. The vast majority of them bloom but not all can form seeds. Results of researches showed that they have a high resistance to the effects of adverse factors. All types of this family are promising for introduction into culture and can be widely used in various branches of the national economy.
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