Annals of Warsaw University of Life Sciences – SGGW
Horticulture and Landscape Architecture No 38, 2017: 43–50
(Ann. Warsaw Univ. of Life Sci. – SGGW, Horticult. Landsc. Architect. 38, 2017)
DOI 10.22630/AHLA.2017.38.5

Schisandra chinensis in the collection of the M. Grishko National Botanical Garden of the Ukrainian NAS in Kyiv

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Abstract: Schisandra chinensis *in the collection of the M. Grishko National Botanical Garden of the Ukrainian NAS in Kyiv*. Results are presented from research into the history of the introduction of *Schisandra chinensis* at the M. Grishko National Botanical Garden of the Ukrainian NAS in Kyiv, the creation of the collection, and characteristics of the introduced population. Phenological phases of growth of *S. chinensis* introduced in the wood-and-steppe zone of Ukraine are demonstrated, reflecting significant displacement of the plant's rhythm of growth compared with its natural habitat. The paper summarizes the results of selection of *S. chinensis*, carried out with the aim of improving the fruit quality and plant productivity. The pomological and biochemical characteristics of the fruit cultivar Sadovy 1 in the years 2014–2016 are given. The plants of the acquired collection will serve as a good material for further breeding programs.

Key words: *Schisandra chinensis*, history of introduction, introduced population, selection, cultivar, phenology of growth, biochemical composition, morphology, biologically active substances, yield

INTRODUCTION

Diversification of fruit trees with new species and varieties introduced from different botanical-geographical regions is essential for the enrichment of cultural phytocoenoses. The M. Grishko National Botanical Garden of the Ukrainian NAS (NBG) is a well-known center for the introduction, acclimatization and selection of unusual and rare fruit crops, among which introduced species from the Far East are of particular significance. One such species is the magnolia-vine *Schisandra chinensis* (Turcz.) Baill., a member of the genus *Schisandra* Michx. in the family *Schisandraceae* Blume [Saunderth 1997].

The genus *Schisandra* includes 25 species distributed in tropical and subtropical regions of Asia: in north-eastern, central, and south-eastern China (Manchuria), in Korea, in the Far East of the Russian Federation, in the east of Thailand, in Cambodia, Vietnam, Nepal and some regions of India, Burma and Japan, and in North America. The magnolia-vine is a relic plant species, Japan-Manchuria endemic with fragmented East-Asia areal, the only member of the genus *Schisandra* which occurs only in the north-western part of the habitat area of the genus [Kolbasina 2008].

Magnolia-vine has great economic value and is used as a valuable food, ornamental and medicinal plant [Ko et al. 2015]. It is widely used in the decoration of pergolas, gazebos, and walls of buildings. Its fruits have a distinctive taste and contain 3–5% sugars, 6–8% organic

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acids (tartaric, malic, citric, succinic), 15––20 mg% vitamin C, and a rich mineral composition [Slobodchikova 1989].

Magnolia-vine is a medicinal plant which is widely used in medicine as a valuable source of biologically active substances (BAS), such as vitamins of the C, E and P groups, organic acids, pectins, and aromatic substances [Chun et al. 2014, Szopa 2017]. The major BAS in magnolia-vine are lignans, mainly schizandrin, γ-schizandrin and schizandrol, which can be found in all parts of the plant [Wang et al. 2003]. Thus, magnolia-vine-based preparations have been used since ancient times as tonics for physical fatigue, exhaustion and nervous overload, neurasthenia, and hypotension – Chinese and Tibetan healers used them as early as the fifth century AD [Lebeda 2004, Kolbasina 2008]. They restore lost performance, eliminate fatigue, increase the quality of night vision, stimulate the regeneration of tissues, and tone the respiratory, central nervous and cardiovascular systems. The fruits of magnolia--vine are recommended in the treatment of bronchial asthma and diseases of the liver and kidneys; the flowers, shoots, leaves and roots of the plant also have medicinal properties [Kolbasina 2008]. In China, magnolia-vine has since the 16^{th} century been included in the first category of drugs recommended for recuperation from fatigue and to improve vigor.

Due to the reduction of natural populations of *Schisandra chinensis*, the periodicity of fruiting and growing demand for fruits and seeds as a medicinal raw material, cultivation of the plant outside its natural habitat area is of great interest [Kharkevich and Kachura 1981].

MATERIAL AND METHODS

The NBG is located in the southern part of Kyiv on the Kyiv elevation, and its area is geomorphologically associated with the large Dnieper elevation. The main type of soil is dark gray ashy. The soil surface is very blurred, with clay loam texture, and is characterized by low humus content (2–4%). The climate of the area in which Kyiv is located is moderately continental with an average annual temperature of 9.4°C. The reported studies were conducted in the years 2014–2016. The mass fraction of dry soluble substances was determined by a refractometric method as in [GOST 28562-90, 1990]; acidity in terms of citric acid was determined by titration with 0.1M NaOH as in [GOST 23555.0-82, 1984]; ascorbic acid content was determined by an iodometric method [Pleshkov 1976]; total sugars were determined by a ferricyanide method as in [GOST 8756.13-87, 1988].

RESULTS AND DISCUSSION

Schisandra chinensis is a monoecious, rarely dioecious, perennial plant. The deciduous, woody climbing vine reaches 8 (15) m in length and 2 cm in diameter (Fig. 1). The shoots in most cases begin at the sympodial stringed brown-reddish roots which irradiate from the root collar of the parent vine at a depth of 10–15 cm. The roots have additional roots, scaly leaves and numerous lenticels. Young vegetative shoots during growth rotate to the left and entwine the trunks of trees or branches of bushes, climbing clockwise up to 1–1.5 m during

FIGURE 1. *Schisandra chinensis*

a

b

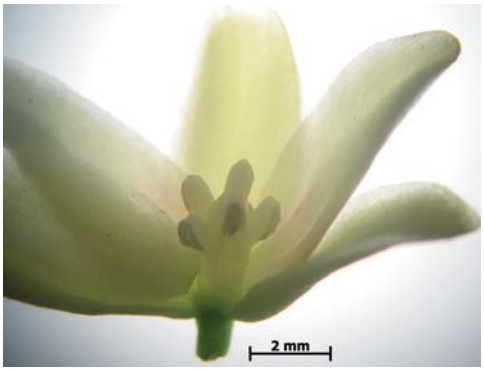

FIGURE 2. *Schisandra chinensis* flowers: a – female; b – male

the growing season. The bark of young shoots is glossy, red-brown, rarely covered with rounded lenticels; the bark of old shoots is reddish brown. The leaves are alternate, simple, entire, elliptical or obovate, 5–10 cm long, 3–5 cm wide, acute, with wedge-shaped base, mildly dentate margin, dark green, with red petioles up to 3 cm long, and with slightly pubescent veins on the abaxial surface. The flowers are dioecious (rarely bisexual), with a simple spirally arranged perianth, fragrant, up to 2 cm in diameter, numbering usually 3–5 in the leaf axils on drooping stalks up to 4 cm long (Fig. 2). The perianth consists of 6–9 whitish segments, with numerous stamens fused in a column unilocular ovary. After flowering, the receptacle greatly (40–50 times) extends and reaches 7–9 cm in length; it bears red, very juicy, spherical, two-seeded follicles (Fig. 3). All parts of the plant have an odor that resembles the smell of lemon. The plants are entomophilous.

Establishment of a botanical-geographical “Far East” section was planned at the NBG as early as 1938––1939, according to the general plan of O.I. Sokolovsky and G.O. Stepunin [Tehnorabochij proekt... 1961]. However, World War II hindered the implementation of those plans, and work began only in 1945–1946. The section presents the main floristic complexes of the Far East: Manchurian with cedar-deciduous, oak,

a

b

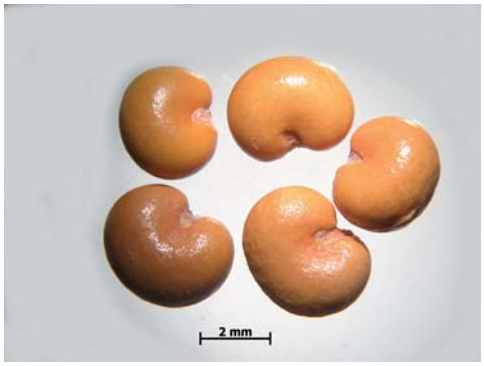

FIGURE 3. Fruits (a) and seeds (b) of *Schisandra chinensis*

and floodplain forests (the area populated by *Schisandra chinensis*), Okhotsk spruce-deciduous forest, and the East Siberian forest with predominance of larch and Daurian birch [Kushnir 2010].

Seeds of *Schisandra chinensis* were first obtained in 1949 at the Khabarovsk Research Institute of Forestry. The second successful attempt was made in 1951 in the Suputinsky natural reserve of Primorsky Region. Later, in 1966, the scientist O.O. Pirozhenko brought from an expedition to the Primorsky Region the seeds of nearly 100 species of Far East flora (including the magnolia-vine). The seedlings were planted in the botanical-geographical section [Kushnir 2010].

According to Y.K. Gotsyk, nearly 16% of seedlings began to bear fruit in the third year after planting. In ten years, magnolia-vine plants became thickly woven in the trees, reaching a height of 3 m [Kharkevich 1972]. Today, there is a stable introduced population with all vegetation ages in the "Far East" botanical-geographical section, where *S. chinensis* reproduces both by seeds and vegetatively. This introduced population was a source of promising forms for local reproduction, which later became the initial selection material.

Selection of magnolia-vine as a fruit crop was begun at the NBG by I.M. Shaytan in the 1950s. The seeds were obtained from Ivanovo (Russia) and by local reproduction. As a result, a collection of *S. chinensis* was formed, now containing more than 200 plants. The collection is represented by highly productive forms characterized by resistance to pests and diseases, winter hardiness and large fruits. The promising form Sadovy 1 was selected from the grown seedlings (in 1959); after testing it acquired the status of a cultivar and was entered in the Ukrainian register of plant cultivars. The plant shoots grow intensely, and fruiting is abundant (3–5 kg of fruits per shrub) and yearly [Klimienko and Skrypchenko 2013]. Flowers are mostly unisexual (male stamens or female pistillate), actinomorphic, and single with a simple perianth. They bloom in early or mid-May. After pollination, the female flower receptacle is extended and takes the form of a spicate inflorescence (polyfollicle). This inflorescence contains on average 24 ±6 roundish berries weighing 0.5–0.7 g each, the average weight of a polyfollicle being 10.7 ±1.7 g. The fruits ripen in

late August to early September. The berries are very juicy when ripe, soft, with a unique taste: the skin and flesh are sour and sweet, the seeds bitter and astringent, and when stored, after some time they acquire a fifth, brackish taste and lemon aroma. According to our analysis, the fruits contain up to 15.5% sugars and 79.2 mg% vitamin C (Table). The acidity of the fruits is 1.6–4.1%. Notably, the sugar and ascorbic acid contents are significantly higher in the introduced *Schisandra* fruits than in the fruits from the plant's natural habitat (9.5% and 22–35 mg%), while the fruit acidity is three times higher. The seeds of magnolia-vine are large, kidney-shaped, and high in oils (33.8%) [Jurenko et al. 2008] and essential oils (1.5–1.7%) [Skrypchenko et al. 2014] with a rich mineral complex of macro- and microelements [Skrypchenko et al. 2017].

Later, a promising form of magnolia-vine with exclusively female flowers was selected from the locally reproduced seedlings.

Long-term phenological observations showed that the plant's vegetation seasons from early spring sap flow to complete defoliation are almost the same, 185 days on average (Fig. 4), in the Far East of Russia and in the wood-and-steppe of Ukraine. As an example of comparison of differences in the phenological development of *S. chinensis* plants in different conditions, the results of the observations in the wood-and-steppe of Ukraine from 2015 are compared with a reference [Kolbasina 2008]. It should be noted that the climate of the Far East of Russia is temperate monsoon. Winter is dry and cold. Spring is long, cool, with frequent temperature fluctuations. Summer is warm and humid; maximum precipitation occurs in the summer months. Autumn, as a rule, is warm, dry, with clear weather. Precipitation is 550–920 mm per year. The duration of sunshine is more than 2,000 h per year. By comparison, the Kyiv climate is temperate continental with mild winters and warm summers. The total duration of sunshine per year is 1,927 h, and average annual precipitation is about 619 mm.

The plants are found to be highly adaptable to the conditions of their place of introduction. The data given on the successive phenological phases of the plants in Kyiv conditions reflect a significant shift of its rhythm of growth in comparison with natural habitats. Thus, in Kyiv, the vegetation of magnolia-vine begins more than a month earlier than in the natural habitat. A similar pattern is noted for other phases of plant development.

TABLE. Biochemical characteristics of *S. chinensis* fruits

Cultivar	Year	Dry mass (%)	Titratable acidity (%)	Total sugar (%)	Vitamin C (mg/100 g)
Sadovy 1	2014	16.1 ±1.3	4.1 ±0.3	11.3 ±0.9	46.3 ±3.8
Sadovy 1	2015	14.9 ±1.2	1.6 ±0.1	13.5 ±1.2	59.2 ±4.8
Sadovy 1	2016	16.6 ±1.2	1.4 ±0.1	10.9 ±1.0	44.1 ±3.7
S. chinensis in nature [Kolbasina 2008]	–	15.0	5.7	9.5	27.5

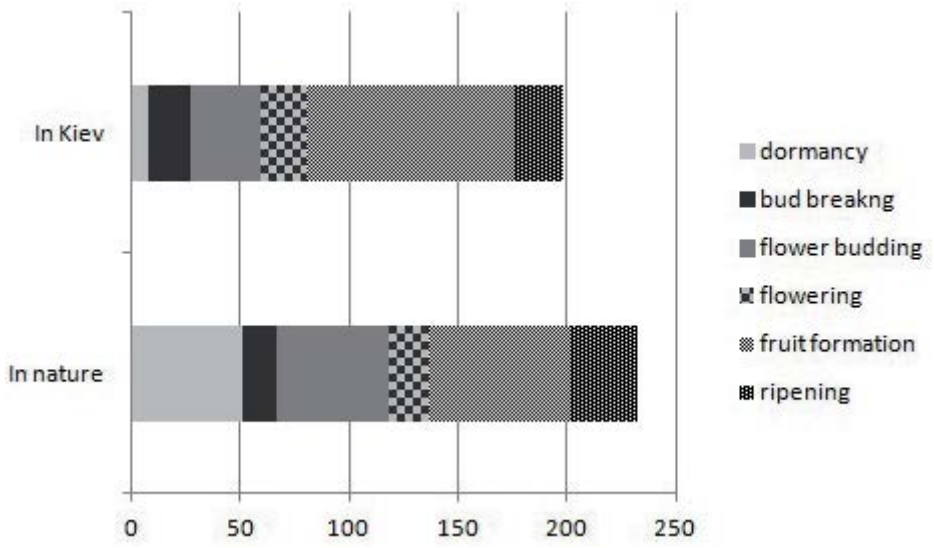

FIGURE 4. Phenological phases of development of *S. chinensis* in nature and when introduced in the wood-and-steppe zone of Ukraine (2015)

Introduction is associated with the accelerated flowering of plants, which according to long-term observations starts at the end of April or early May and ends in the last ten days of May. In nature, magnolia-vine blooming begins in late June and ends mid-July. The time of blooming is mostly the same in introduction and in nature, lasting for about 18 to 20 days. The period of fruit formation is increased from 67 days in nature to 137 days under introduction. In the wood-and-steppe zone of Ukraine the fruits start ripening by the end of August, while in nature this begins only in the last 10 days of September. The introduction conditions allow the full cycle of development of the magnolia-vine to conclude. The length of the vegetation period from the start of spring sap flow to the complete defoliation of the plants is 180–183 days in the Far East, and 200–203 days in the wood-and-steppe zone of Ukraine (on the right bank of the Dnieper river).

CONCLUSIONS

1. In the “Far East” botanical-geographical section of the M. Grishko National Botanical Garden of the Ukrainian NAS there is a stable population of *Schisandra chinensis* containing plants of all ages freely reproducing both by seeds and vegetatively.
2. The *Schisandra chinensis* collection at the NBG is a foundation for scientific research and a valuable source for the selection and creation of new magnolia-vine cultivars of high economic quality, as proved by the selected forms and the Sadovy 1 cultivar.
3. According to the results of phenological observations, magnolia-vine

in the conditions of the right-bank wood-and-steppe zone of Ukraine completes its cycle of development and can be cultured for further use as a valuable food, decorative and medicinal plant. The fruit formation period under the conditions of introduction is twice as long as in the plant's natural habitat area, and this may affect the biochemical composition of the fruits and the vegetative mass.

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Streszczenie: Schisandra chinensis *w kolekcji Narodowego Ogrodu Botanicznego im. M. Griszka Akademii Nauk Ukrainy w Kijowie*. W pracy przedstawiono wyniki badań nad historią wprowadzenia, tworzenia kolekcji i wprowadzania populacji *Schisandra chinensis* w Ogrodzie Narodowym im. M. Griszka Akademii Nauk Ukrainy w Kijowie. Rytm wzrostu (przebieg faz fenologicznych) *S. chinensis* w badanej strefie Ukrainy (las-step) odbiegał znacząco od rozwoju roślin występujących na naturalnym siedlisku przyrodniczym tego gatunku. W pracy przedstawiono wyniki selekcji *S. chinensis* w celu poprawy jakości owoców oraz produktywności rośliny. Przedstawiono właściwości pomologiczno-biochemiczne odmiany Sadovy 1, oceniane w latach 2014–2016. Rośliny, które zgromadzono w kolekcji, są dobrym materiałem do dalszych programów hodowlanych.