

## Prospects for the introduction of ornamental plants of the genus Sage (*Salvia* L.) to the Forest-Steppe of Ukraine

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**Purpose.** Analysis of species and varietal diversity of the genus *Salvia* L. cultivated flora of the world, including Ukraine; prognostic assessment and determination of the directions of ornamental representatives of the genus introduction to the conditions of the Forest-steppe of Ukraine. **Methods.** Analysis and synthesis, comparison and generalization of information data, introduction forecast. **Results.** The modern assortment of the genus *Salvia* is presented in quantitative, taxonomic, arealogical and ecological-cenotic terms. Belonging of the species of the genus to 6 main centers of origin of cultivated plants was determined, and a significant diversity of life forms (nanophanerophytes, microphanerophytes, hamophytes, hemicyptophytes, theophytes), naturally formed under the influence of factors determined by different geographical and ecological-phytocenotic conditions of plant growth was reflected. Species assortment of the genus *Salvia* from the collection fund of the M. M. Gryshko National Botanical Garden of the National Academy of Sciences of Ukraine was analyzed in comparison with the collections of other Ukrainian botanical gardens. The list of decorative species of the collection, found in the natural flora of Ukraine, was given. Three groups of species have been identified by origin, what determines the conditions for plant cultivation in the Forest-Steppe of Ukraine. In terms of taxonomic structure, introduced sage species belong to eight (according to Bentham, 1833) out of twelve sections, which represent biomorphological diversity and confirm the high introduction potential of these plants. The species and interspecific hybrids most fully used in breeding work and represented by a significant varietal diversity were distinguished, as well as the sage assortment of the collection of ornamental plants of the NBG was presented. **Conclusions.** It has been revealed that the species and varietal diversity of the genus *Salvia* of the world cultivated flora has a significant introduction potential for the Forest-Steppe zone of Ukraine. It was determined that the main base for the introduction of the ornamental species of the genus *Salvia* in Ukraine is the collection of the M. M. Gryshko National Botanical Garden of the National Academy of Sciences of Ukraine. The main directions of further introduction and breeding work with representatives of the genus *Salvia* in the Forest-Steppe conditions of Ukraine were highlighted.

**Keywords:** cultivated flora; plant collections; life forms; habitat; breeding; introduction study.

### Introduction

Ornamental herbaceous plants are an integral part of the green space of urbanized environments, but they are often overlooked by landscape architects. In Ukraine, their assortment remains small and monotonous in terms of floristic composition with insignificant differentiation of plants according to biological and ecological characteristics. The use of new ornamental species from different phytocenes expands the possibilities for the forma-

tion of highly decorative compositions that are resistant to a wide range of environmental factors.

Botanical gardens are the centers of conservation, enrichment and research of biological and ecological diversity of plants. For several centuries they have been actively promoting the development of floriculture. Collections of introduced plants serve as a potential source of expansion and diversity in the assortment. The theoretical results of the introduction research are used in the development of technological maps for the cultivation of crops.

Due to persistent trends in climate change [1–3], the issues of forming an assortment of floral and ornamental plants characterized not only by high decorativeness, but also by a wide

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ecological amplitude of its representatives, are of particular relevance today.

With the intensification of the processes of climate aridization and xerophytization of the vegetation cover in the Forest-Steppe zone of Ukraine during the formation of artificial plantations of urbanized landscapes, xeromesophytes, mesoxerophytes and xerophytes exhibit high resistance. Representatives of the genus *Salvia* L. are promising in this case, most of which belong to the aforementioned hygromorphs, and the plants are characterized by abundant long flowering.

Now the species of the genus are widely represented in the world floriculture, active selection work with them expands the decorative properties of plants. Today, only *S. splendens* Sell ex Roem & Schult is found in the landscaping of our cities., occasionally single varieties of *S. × sylvestris* L., but other, more efficient species are ignored. Considering the small range of crops in Ukrainian floriculture and persistent changes in climatic conditions, which dictate the demand for ecologically plastic and drought-resistant plants, and based on the experience of cultivating *Salvia* in Western Europe and North America, we believe that these plants are a promising source for enriching the domestic range of ornamental plants. This actualizes the introduction research of species and varieties of the genus, preceded by the study and analysis of their world assortment and the assessment of the prospects for further introduction in Ukraine.

*The purpose of the research* is to analyze the species and varietal diversity of the genus *Salvia* of the cultivated flora of the world, including Ukraine; prognostic assessment and determination of the directions of introduction of ornamental representatives of the genus into the conditions of the Forest-Steppe of Ukraine.

### Materials and methods

We used the inventory data of the collection funds of the NBG, the database of floral and ornamental plants (FOP) of the botanical gardens of Ukraine, reference books, and catalogs in the research process [4–6]. Printed and electronic scientific periodicals and search scientific bases (Pubmed, Researchgate, Science Direct, Google Scholar) were used in information retrieval. Methods of analysis, systematization, comparison, generalization of information data were used in the work. The introduction forecast was carried out according to the methods [7–9].

The genus size and its structure are taken according to the taxonomic system APG III [10, 11]. Data on the species and varietal composition of the genus *Salvia* in ornamental horticulture were taken from the consolidated lists and catalogs of flower producers and trading companies around the world [12–15]. The life forms of plants were determined in accordance with the classification of I. G. Serebryakov [16] and C. Raunkiaer [17].

### Results and discussion

According to scientific sources on the development of world floriculture, there is a great interest in the representatives of the genus *Salvia* as ornamental plants, and the constant expansion of their range in ornamental gardening in many developed countries of the world. Enrichment of the assortment is due to the introduction of new species and targeted breeding to create new interspecific hybrids and varieties.

*Salvia* is the most numerous cosmopolitan polyphyletic polymorphic genus of the family Lamiaceae Martinov., with a complex taxonomic structure. According to the results of morphological and molecular phylogenetic studies, it numbers about 1000 species [11, 15, 18–21]. The natural area covers tropical, subtropical and temperate areas, mainly mountain ranges and open dry plains. The genetic center of origin of *Salvia* is considered to be the mountain ranges of Southwest Asia. In the process of area expansion, the main migration routes, obviously, passed along the mountain chains. Isolation and a variety of microecological conditions prompted intensive speciation, which led to the formation of peculiar phylogenetic groups in different parts of the range and the formation of a large species diversity. The main directions of shaping processes are associated with its evolution on the way to xerophytization. Now there are three regions with the highest species diversity: Central and South America (about 500 species), Central Asia and the Mediterranean (~ 250), East Asia (~ 90) [13, 18–22]. In Europe, 36 species grow [15, 23], in particular in Ukraine – 20 [24, 25]. Among the latter, *S. scabiosifolia* Lam., *S. cremenecensis* Bess. (= *S. nutans* L.) are included in the Red Book of Ukraine [26].

The centers of species diversity of the genus *Salvia* are associated with the main world centers of origin of cultivated plants identified by N. I. Vavilov: South, East and Southwest Asia, Mediterranean, Ethiopian, Andean, Central American [27]. Bazilevskaya N. A. [28], working on the development of centers of origin

of ornamental plant species, identified another additional region – the South African Center for the variety of sage, in particular sections Heterospace and Nactospace.

The wide range of the genus and various ecological and phytocenotic growth conditions have led to a significant variety of life forms of sage. Among them are herbaceous one-, two- and perennials, subprostrate shrubs, prostrate shrubs, subshrubs, and occasionally shrubs (according to C. Raunkiaer classification, therophytes, cryptophytes, hemicryptophytes, hamephites, phanerophytes are distinguished). In the temperate zones of natural flora, hemicryptophytes are mainly found.

In the world floriculture, all main types of life forms characteristic of *Salvia* are now represented: nanophanerophytes, microphanerophytes, hamephites, hemicryptophytes, therophytes. One third of the entire assortment is made up of nanophanerophytes, microphanerophytes and hamephites, which are spring-summer-autumn-winter-green, or evergreen by phenorhythm. Hemicryptophytes, among which taproot semi-rosette polycarpic herbaceous plants predominate, are spring-summer-autumn-winter-green. Rosetteless polycarpic herbaceous plants are spring-summer-autumn-green.

The success of the introduction of some species of the genus into the conditions of the Forest-Steppe of Ukraine depends on the life form of plants. Phanerophytes prevail in the tropical zone with sufficient uniform moisture throughout the year. With a decrease in the sum of active temperatures and an increase in continentality of the climate, the percentage of hamephites increases. Hemicryptophytes are characteristic of the temperate climatic zone; in the subtropics, they are found in humid areas or in high mountain zones. Therophytes are present in various parts of the genus range [22]. Therefore, the most promising for further introduction is the Forest-Steppe of Ukraine are therophytes and hemicryptophytes, which also prevail in the natural flora of Ukraine. Hamephites are also quite promising, but they are not always winter-hardy under conditions of introduction.

The lability of the life form of plants significantly increases the introduction capacity of sage in culture. This is most pronounced in phanerophytes (subshrubs, shrubs, subprostrate shrubs), it is most stable in hemicryptophytes (herbaceous polycarpics) [22]. The most popular in floriculture are annual crops that originate from the regions of Central and South America and usually grow in their natural range as subprostrate shrubs (*S. splen-*

*dens*) or seasonless polycarpic grasses (*S. farinacea* Benth.). The species *S. canariensis* L., newly introduced in the NBG, endemic to the flora of the Canary Islands, manifests itself as an upright bush at home. In the case of its introduction, the life form changes to a subprostrate shrub. In the first year of vegetation, the plants bloom profusely and form full-fledged seeds, but they are not winter-hardy. Therefore, for the conditions of the Forest-Steppe of Ukraine, we consider this species to be a promising annual crop.

As a result of spontaneous introduction and purposeful introduction research, there are currently about 200 sage species and more than 300 of their varieties recommended for use in the world assortment of ornamental crops [12]. More than 17 sage species are used in floriculture and gardening in Western Europe. Approximately 10% of the total assortment of ornamental species is cultivated as a one- or two-year culture [12–14, 29, 30]. Among the best known are *S. pratensis* L., *S. nutans*, *S. nemorosa* L., *S. sclarea* L., which originate from the steppe, meadow-steppe phytocenoses of Eurasia, *S. glutinosa* L. – from the forests of Eurasia, *S. officinalis* L. – from dry slopes, open forests and lawns of the Mediterranean, *S. viridis* L. – from dry sandy shrub landscapes, open forests of the Mediterranean and North-West Asia, *S. verticillata* L. – from dry meadows of the Mediterranean, naturalized in Eurasia, *S. argentea* L. – from dry meadows of the Mediterranean, North Africa, *S. cacaliifolia* Benth., *S. chamaedryoides* Cav., *S. greggi* A.Gray, *S. microphylla* Kunth, *S. patens* Cav., *S. regla* Cav. – from dry rocky slopes of Central America, *S. azurea* Michx. ex Vahl – from the prairies and savannas of Central America, *S. elegans* Vahl – from the mountain pine-oak forests of Central America, *S. jurisicii* Kosanin – from the mountain meadows of the Balkan Peninsula, endemic to Macedonia. Some of them have already been successfully introduced as ornamental plants in the NBG (*S. argentea*, *S. glutinosa*, *S. nemorosa*, *S. officinalis*, *S. pratensis*, *S. verticillata*, *S. viridis*), others are promising for further introduction work in the NBG, which have already been introduced into the culture and for them the foundations of agricultural technology have been developed, but they need to be adapted to the new conditions of the introduction of the Forest-Steppe of Ukraine.

In general, species diversity is an inexhaustible genetic resource for breeding work in order to expand the range of decorative traits and ecological plasticity of plants and, as a

consequence, diversity of their assortment. Now in breeding work such species as *S. cleve-landii* (A.Gray) Greene, *S. coerulea* Benth., *S. elegans*, *S. farinacea*, *S. greggii*, *S. involucrata* Cav., *S. madrensis* Seem., *S. microphylla*, *S. nipponica* Miq., *S. officinalis*, *S. splendens*, *S. patens*, *S. pratensis*, *S. verticillata* and some others are involved and represented by varietal diversity. The main breeding centers were formed in the USA, Europe, Japan [31].

However, most of the varieties spread recently are interspecific hybrids. The first interspecific hybrids arose spontaneously in natural conditions; subsequently, they began to be selected by spontaneous hybridization during cultivation. Targeted experimental interspecific crosses began to be carried out in the second half of the twentieth century in order to obtain both high-grade essential oil bearing and highly decorative varieties [29, 31]. Several groups of interspecific hybrids are widely used in floriculture. A hybrid of *S. greggii* and *S. microphylla* is known as *S. × jamensis* J.Compton. It is a natural interspecific hybrid first found in the Mexican mountains. In decorative gardening, it is represented by more than ten highly decorative varieties. The herbaceous interspecific hybrid *S. × sylvestris*, which comes from *S. pratensis* and *S. nemorosa*, whose varieties can be derived from other Eurasian species, is stable in the conditions of the Forest-Steppe of Ukraine. When creating new varieties, polyploidy methods are sometimes also used [29, 32].

Along with intensive selection work, scientific research on the introduction of new species into culture, including local flora, especially in regions rich in natural species diversity, remains relevant at the present time [33, 34].

The introduction into culture is preceded by the introduction and introduction research of plants with the following recommendations for their widespread use. The first stage in the introduction process is the prognostic assessment and formation of the collection fund of the world diversity of *Salvia*, which will serve as a source material for highly decorative promising species and varieties in the future.

At present, 35 species of the genus *Salvia* are collected in the botanical gardens of Ukraine, of which 25 species are presented in the collections of the NBG, and 21 species (1.5–2.8% of the species range of the world flora) belong to the collection of ornamental plants [6]. By origin, these species can be attributed to three groups. The first group includes representatives of the American subtropics, which in temperate climates are cul-

tivated as annual plants (*S. canariensis*, *S. farinacea*, *S. splendens*, *S. tiliifolia* Vahl., *S. coccinea* Juss. Ex Murray). The second group includes species of Mediterranean origin that are more resistant to drought and cold (*S. argentea*, *S. jurisicii*, *S. viridis*, *S. virgata* Jacq., *S. verticillata*, *S. officinalis*, *S. judaica* Boiss., *S. tomentosa* Mill.) and are grown as annual plants, covering or non-covering perennials. *S. officinalis*, *S. tomentosa*, *S. verticillata* are quite winter-hardy, grown as perennial non-covering crops. *S. verticillata* has successfully naturalized over a large area of Europe. The third group unites cold-resistant Eurasian species, which are perennial ornamental plants with a characteristic abundant flowering. Their range passes through the flat and high-mountain steppes and dry meadows of Europe (*S. forsskaolei* L., *S. transsylvanica* (Schur ex Griseb. & Schenk) Schur, *S. verbenaca* L.), Europe and North-West Asia (*S. nemorosa*, *S. pratensis*), Northwest Asia (*S. atropatana* Bunge, *S. cadmica* Boiss.). Plants are unpretentious to soil and climatic conditions, among them there are shade-loving ones, for example, the Eurasian species *S. glutinosa*. In nature, it grows in humid forests, but in culture it shows sufficient tolerance to drought.

Additionally, the collections of medicinal and aromatic plants of the NBG contain sage species such as *S. aethiopsis* L., *S. nutans*, *S. patens*, *S. sclarea*. They are characterized by pronounced decorative properties and can be included in the introduction study for further use in landscaping.

In total, the collection funds of the the NBG contain 10 species that are found in the natural flora of Ukraine, some of them are naturalized (*S. aethiopsis* L., *S. glutinosa*, *S. nemorosa*, *S. nutans*, *S. pratensis*, *S. sclarea*, *S. tomentosa*, *S. virgata*, *S. verticillata*, *S. verbenaca*).

In taxonomic terms, the collections of living plants of the the NBG include eight species (according to Bentham, 1833) of twelve sections (Table 1), which represent the biomorphological diversity of the genus and confirm their high introduction potential for this region.

Varietal diversity of sage of the NBG floral and ornamental plants collection is represented by 24 cultivars (Table 2). *S. splendens* with 14 varieties is the most represented species. *S. coccinea* and *S. viridis* have three varieties, *S. farinacea* – two. The perennial sage assortment is less diverse: *S. nemorosa* and *S. × sylvestris* are represented by only one cultivar.

All the aforementioned cultivars have successfully passed the introductory variety trials

Table 1

**Taxonomic structure of the collection fund of the genus *Salvia* L. of the M. M. Gryshko National Botanical Garden of the National Academy of Sciences of Ukraine**

Section	Species
Salvia	<i>S. officinalis</i> L., <i>S. tomentosa</i> Mill.
Drymosphace	<i>S. glutinosa</i> L., <i>S. forsskaolei</i> L.
Horminum	<i>S. viridis</i> L.
Aethiopsis	<i>S. aethiopsis</i> L., <i>S. argentea</i> L., <i>S. atropatana</i> Bunge, <i>S. sclarea</i> L.
Plethiosphace	<i>S. cadmica</i> Boiss., <i>S. pratensis</i> L., <i>S. transsilvanica</i> Schur., <i>S. nemorosa</i> L., <i>S. nutans</i> L., <i>S. judaica</i> Boiss., <i>S. jurisicii</i> Kusanin, <i>S. verbenaca</i> L., <i>S. virgata</i> Jacq.
Calosphace	<i>S. coccinea</i> Juss. ex Murray, <i>S. splendens</i> Sellow ex Schult., <i>S. tiliifolia</i> Vahl., <i>S. patens</i> Cav., <i>S. farinacea</i> Benth.
Heminosphace	<i>S. verticillata</i> L.
Hymenosphace	<i>S. canariensis</i> L.

Table 2

**Varietal composition of the genus *Salvia* L. in the collection of floral and ornamental plants of the M. M. Gryshko National Botanical Garden of the National Academy of Sciences of Ukraine**

Species	Varieties
<i>S. splendens</i>	'Aticolavander', 'Brasier', 'Bonfine', 'Jans Vuur', 'Kometa', 'Libochovickyohen', 'Rakette', 'Red', 'Rio', 'Roodcopje', 'Scarlet Piccolo', 'Sizzler', 'Sizzler White', 'Violaceae'
<i>S. coccinea</i>	'Coral Nymph', 'Rosea', 'Pseudococcinea'
<i>S. viridis</i>	'Alba', 'Camate', 'Violacea'
<i>S. farinacea</i>	'Blue Monarch', 'Belyy Lebed'
<i>S. nemorosa</i>	'Rosa Konigin'
<i>S. × sylvestris</i>	'Blue Queen'

and are recommended for mass use in the landscaping complex of Ukraine.

Among *Salvia* species introduced in other botanical gardens of Ukraine, we see promising prospects in the study of *S. aucheri* Benth., *S. barrelieri* Etl., *S. dumetoru* Andrzej. ex Besser, *S. officinalis* subsp. *lavandulifolia* (Vahl) Gams, *S. staminea* Montbret & Aucher ex Benth.

According to the literature data [22], *S. amasiaca* Freyn et Bornm, *S. austriaca* Jacq, *S. azurea*, *S. deserta* Schangin, *S. haematodes* L., *S. hierosolymitana* Boiss., *S. hispanica* L., *S. przewalskii* Maxim., *S. stenophylla* Burch. ex Benth., *S. taraxacifolia* Coss. ex Hooker f., *S. viscosa* Jacq have been successfully introduced and cultivated as ornamental species in the Forest-Steppe zone of other countries. In the future, it would also be advisable to add them to the NBG floral and ornamental plants collection and to determine their prospects for use in landscape design.

Species that have recently appeared in culture are promising for introduction. They are very decorative and thermophilic plants distinguished by significant drought tolerance, in particular *S. discolor* Kunth, *S. guaranitica* A.St.-Hil. ex Benth., *S. uliginosa* Benth., *S. regla* [35, 36]. Among them, the original and exotic species – *S. discolor*, which comes from the Peruvian Andes forests, at an altitude of 1800–2500 m. It is characterized by a dark blue, almost black color of the bracts surrounded by silvery calyces. The South American species

*S. guaranitica* and *S. uliginosa* belong to the most beautiful, luxurious and tall (up to 1.5–1.8 m) representatives of the genus, which create a cold scale in flower gardens. *S. guaranitica* is characterized by textured, wrinkled leaves with anise aroma, while *S. uliginosa* is characterized by small (up to 7 cm) elongated leaves dissected along the edge and bright blue-blue flowers. The originality of the Texas species *S. regla* is that it grows in diameter more (up to 100 cm) than in height. In temperate latitudes, it is advisable to grow these plants as an annual crop and actively use them in breeding work.

### Conclusions

The species and varietal diversity of the genus *Salvia* of the the world cultivated flora is characterized by a significant potential for introduction into the Forest-Steppe of Ukraine. The collection of the genus *Salvia* of the M. M. Gryshko National Botanical Garden is a valuable source of donors of selectively valuable traits for the creation of new highly decorative resistant domestic varieties, as well as the basis for further introduction research of ornamental species of this genus. Based on the analysis of scientific sources on the use of ornamental species and varieties of *Salvia* in the world, their distribution in the natural flora of Ukraine and collection funds of botanical gardens in Ukraine, the main directions of further introduction of representatives of the genus as ornamental crops in the Forest-Steppe

conditions of Ukraine are highlighted. First of all, these are:

1) introduction of representatives of the cultivated world flora, which have already gone through the process of introduction in other climatic zones. For them, the foundations of agricultural technology have been developed, but they need to adapt to the edapho-climatic conditions of the Forest-Steppe of Ukraine;

2) introduction studies of new wild-growing species and forms, including those from the natural flora of Ukraine, which were not previously used for decorative purposes;

3) introduction of rare and endangered taxa for their preservation in cultural conditions;

4) introduction of species and interspecific hybrids, which are used in breeding work and characterized by a high degree of polymorphism in terms of qualitative and quantitative characteristics, as well as modern varieties that reflect world trends in the development of floriculture.

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**Перебойчук О. П.**<sup>\*</sup>, **Машковська С. П.** Перспективи інтродукції декоративних рослин роду Шавлія (*Salvia* L.) у Лісостеп України. *Plant Varieties Studying and Protection*. 2021. Т. 17, № 2. С. 91–98.  
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**Мета.** Аналіз видового та сортового різноманіття роду *Salvia* L. культивованої флори світу, зокрема й України; прогностична оцінка та визначення напрямів інтродукції декоративних представників роду в умови Лісостепу України. **Методи.** Аналіз і синтез, порівняння та узагальнення інформаційних даних, інтродукційний прогноз. **Результати.** Представлено сучасний асортимент роду *Salvia* в кількісному, таксономічному, ареалогічному та еколого-ценотичному відношенні. Визначено приналежність видів роду до шести основних центрів походження культурних рослин, а також відображено значне розмаїття життєвих форм (нанофанерофіти, мікрофанерофіти, хамефіти, гемікриптофіти, терофіти), які закономірно сформувалися під впливом чинників, що визначалися різними географічними та еколого-фітоценотичними умовами зростання рослин. Проаналізовано видовий асортимент роду *Salvia* колекційного фонду Національного ботанічного саду імені М. М. Гришка НАН України (НБС) порівняно з колекціями інших ботанічних садів України. Наведено перелік декоративних видів колекції, що трапляються в природній флорі України. Виділено три групи видів за походженням, які й визначають умови культивування

рослин у Лісостепу України. За таксономічною структурою інтродуковані види шавлій належать до восьми (згідно з Bentham, 1833) з дванадцяти секцій, які представляють біоморфологічне різноманіття та підтверджують високий інтродукційний потенціал цих рослин. Виділено види й міжвидові гібриди, які найбільш задіяні в селекційній роботі та репрезентовані значним сортовим розмаїттям, а також представлено асортимент шавлій колекції квітничково-декоративних рослин НБС. **Висновки.** Установлено, що видове та сортове різноманіття роду *Salvia* культивованої флори світу має значний інтродукційний потенціал для лісостепової зони України. Визначено, що основною базою для інтродукційного вивчення декоративних видів роду *Salvia* в Україні є колекція Національного ботанічного саду імені М. М. Гришка НАН України. Виокремлено основні напрями щодо подальшої інтродукційної та селекційної роботи з представниками роду *Salvia* в умовах Лісостепу України.

**Ключові слова:** культивована флора; колекції рослин; життєві форми; ареал; селекція; інтродукційне дослідження.

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