

ECOLOGY, BIOTECHNOLOGY, AGRICULTURE AND FORESTRY

IN THE 21ST CENTURY

PROBLEMS AND SOLUTIONS



EDITED BY
S. STANKEVYCH, O. MANDYCH

**ECOLOGY, BIOTECHNOLOGY, AGRICULTURE
AND FORESTRY IN THE 21ST CENTURY:
PROBLEMS AND SOLUTIONS**

Edited by S. Stankevych, O. Mandych

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The monograph is a collection of the results of scientists' achievements obtained directly in real conditions. The authors are recognized specialists in their fields, as well as young scientists and graduate students of Ukraine. The studies are conceptually grouped in sections: biotechnology, ecology, agriculture, forestry, sustainable development of the economy and the principles of effective agribusiness. The monograph will be of interest to specialists in biotechnology, ecology, breeding, plant protection, agrochemistry, soil science, forestry, agribusiness, etc., researchers, teachers, graduate students and students of specialized specialties of higher educational institutions, as well as everyone who is interested in sustainable development in the agricultural sphere and Green Deal Implementation strategies.

Keywords: sustainable development, modern technologies, agricultural production, biotechnology, ecology, plant protection, forestry, agribusiness.

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SECTION 4. FORESTRY

**FEATURES OF THE GROWTH AND DEVELOPMENT OF
DECORATIVE SPECIES OF THE GENUS *PAEONIA* L. IN THE
CONDITIONS OF THE ARCHITECTURAL AND EXPOSITION
AREA OF VNAU**

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The monographic study provides an overview of literature data on the history of selection, characteristics and features of growing *Paeonia* L. cultivars and their use in landscaping the architectural and exposition site of the VNAU. Part of the researched varieties of peonies was transferred to the department of forestry and horticulture of VNAU by the department of flower and decorative plants of the National Botanical Garden named after M.M. Hryshka to study their decorativeness in the conditions of the Right Bank Forest Steppe of Ukraine. Currently, the use of peonies in landscaping is unfortunately underutilized, however, considering its high decorative capabilities and ecological and biological features, the culture is quite promising. There are dozens of different types and thousands of varieties of herbaceous peonies in nature, which differ in the structure of flowers, color, height and shape of the bush. Not all of them are suitable for use in landscape design, so there was a need to select varieties that would maximally meet the requirements for morphological, biological and agrotechnological characteristics. The purpose of the work was to establish biometric features with an evaluation of the success of the introduction of species of the genus *Paeonia* L. in the conditions of Podillia for the further greening of the park zone of VNAU. The research methodology is based on experimental studies of scientific topic: «Development of technology for growing forest, ornamental and fruit and berry plants in the context of balanced development and ensuring ecological sustainability of agro-landscapes of the Forest Steppe of Ukraine» (state registration number: 0123U103579).

Key words: biodiversity, *Paeonia* L., landscaping, landscape design, varietal diversity.

Introduction

Collections of plants in botanical gardens and arboretums are an extremely important source of enrichment of the assortment of floral and decorative, medicinal, agricultural and other plants and centers of preservation and reproduction of unique natural species in ex situ conditions. In connection with the strengthening of anthropogenic influence on natural groups, there is a need to use all possibilities and methods to preserve rare and disappearing plant species. One of these methods is the introduction of plants, which is purposefully carried out by botanical gardens and arboretums. Summarizing the results of the introduction of plants consists in establishing the degree of their stability in new conditions of growth and prospects for further cultivation [1].

Enrichment and renewal of the range of ornamental plants is relevant for any country in the world, including Ukraine. The introduction of new promising varieties selected as a result of many years of research into widespread production practice remains one of the main tasks of breeding [1]. A modern direction in landscaping is the study and introduction of new flower and decorative plants with a sufficient raw material base [2].

Peony plants are promising in this regard, particularly decorative species that have long been used in traditional medicine due to their healing properties. Peonies take a leading place among perennials that are able to overwinter in open ground. High decorativeness, durability and the possibility of wide use in decorative horticulture, ecological plasticity of not only species, but also most varieties make it possible to grow these plants in different climatic zones of Ukraine [3]. The creation of new varieties and their taxonomy will allow to significantly expand the use of peony culture in landscaping and enrich the cultivated flora of the Podillia area and Ukraine as a whole.

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In the field of horticulture, the genus *Paeonia* L. is represented by both a significant number of species (40) and a rich varietal assortment, amounting to more than 5,000 varieties. At the same time, it was found that the assortment of decorative crops of Ukraine includes 5 species, that is, less than 2% of varieties [1-2]. From a practical point of view, all studied varieties and hybrids of Ukrainian and foreign selection are of interest as

potentially valuable objects for enriching the assortment of decorative plants of Ukraine and are promising for creating a monogarden on the basis of Vinnytsia National Agrarian University [2, 7].

Varieties and hybrids of herbaceous species of peonies are presented on the basis of the architectural and exposition area of VNAU. In today's conditions, herbaceous peonies are among the most easily grown hardy perennials. Long-lasting and reliable, peonies can easily grow to 100 years or more. Being a herbaceous perennial, this peony group's annual stem growth continues throughout spring and summer. The death of the stem mass takes place in late autumn, remaining at rest during the winter season [3]. The study of new varieties and observation of their development will allow to significantly expand the use of peony culture in landscaping and enrich the cultivated flora of the Podillia area and Ukraine as a whole.

Research materials and methodology

The research was carried out by processing the biometric indicators of vegetative organs of the peony for the period 2018-2022 in the conditions of the architectural and exposition area of the National Academy of Sciences. The objects of the study are representatives of the genus *Paeonia L.* The Latin names of the plants of the families are given according to the checklist [1]. The decorativeness of plants was evaluated based on a set of signs of vegetative organs, the duration of the decorative period, and resistance to the climatic features of Vinnytsia. The assortment and scheme of planting representatives of the genus *Paeonia L.* in the conditions of the architectural and exposition area of the VNAU are presented in Figure 1: 1. China Maid, 2. Magician, 3. Heritage, 4. Triumph de Nord, 5. Corypheus, 6. Raspberry fire, 7. Antaeus, 8. Mahogany, 9. Diana Parks, 10. Cherry Red, 11. Venus, 12. Sarah Bernard, 13. Reine Hortense, 14. Red sails, 15. Svetoch, 16. Flashlight, 17. Pearl placer, 18. Henry Bockstoe, 19. Mons. Jules Elie, 20. Seraphim, 21. Red velvet, 22. Rubra plena, 23. Tenifolia plena, 24. Thin-leaf steppe, 25. Doreen, 26. Gay Patee, 27. Gold Standart, 28. Hit Parade, 29. Moon of Nippon, 30. Neon, 31. Philomele, 32. Hot Chocolate, 33. White sail, 34. Bridal.

Systematics of the genus *Paeonia L.*

Among the wide range of flower garden and decorative plants, the species *Paeonia L.*, whose representatives occupy one of the most numerous places in the world assortment of ornamental crops, are among the most promising for introduction into Ukraine. Testing grass species will make it

possible to draw preliminary conclusions about the prospects of their cultivation in the conditions of Podillia.

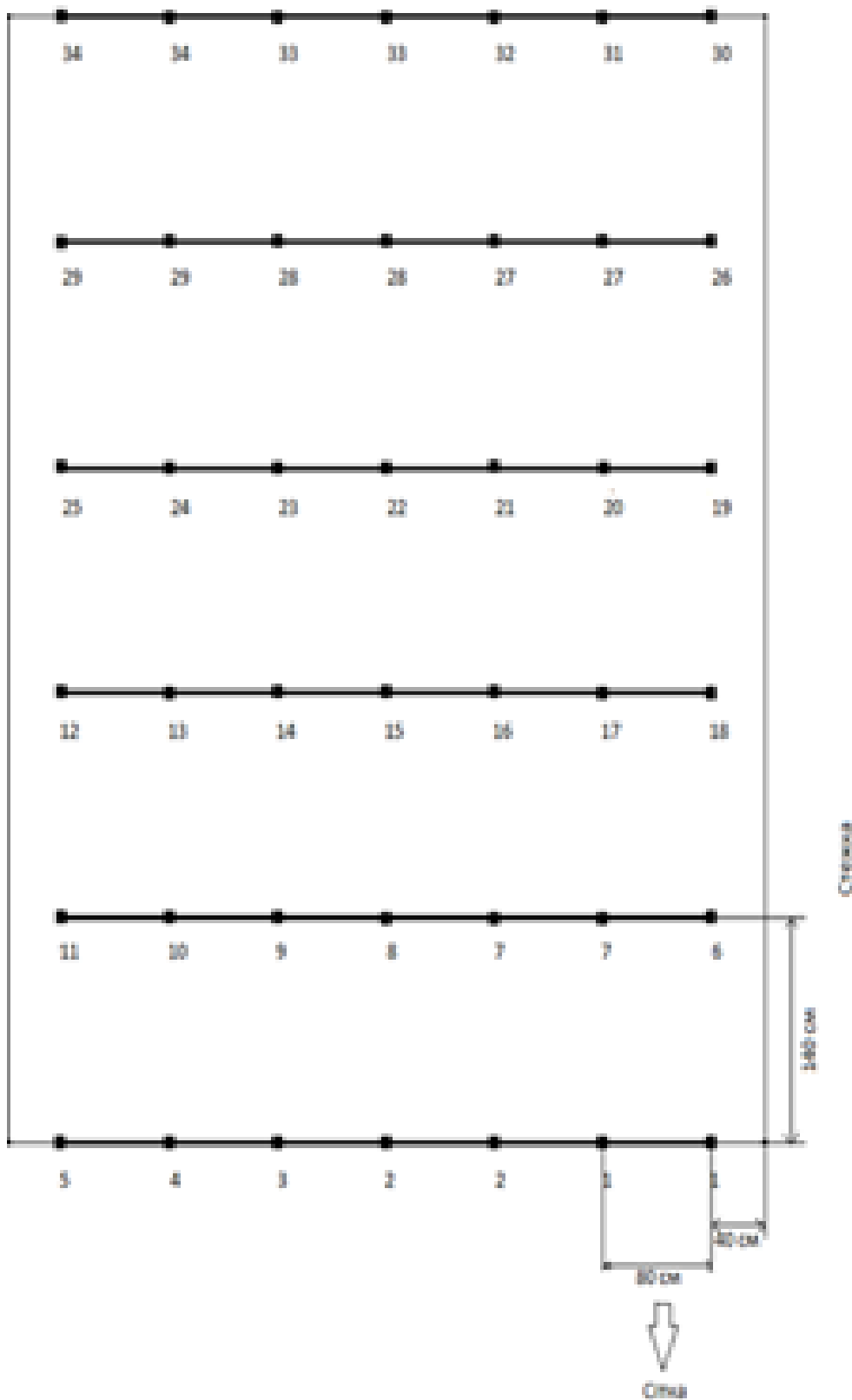


Fig. 1. Planting scheme and range of herbaceous species of the genus *Paeonia L.* in the conditions of the architectural and exposition site of VNAU

Peony culture is a monotypic genus of herbaceous perennials, the only one in the Peony family. There are different types of peonies - not only grass peonies, there are also tree-like peonies, as well as species that combine the properties of both tree-like and grass peonies - about forty species in total. In nature, peony flowers grow in the temperate and subtropical zones of North America and Eurasia.

Paeonia L. belongs to a single genus of herbaceous perennials and deciduous shrubs from the Paeoniaceae family. The genus was first identified by Carl Linnaeus in 1753 in «Species Plantarum 530». It is believed that the name of the genus comes from the name of the Greek physician of the gods Paeon, who cured Ares thanks to the medicinal properties of the plant.

Peonies are common in the middle belt. These are mainly perennial herbaceous plants, less often semi-shrubs or shrubs. In grassy species, the aerial part completely dies in winter; tree peony retains its characteristic sprawling bush throughout the year. In semi-shrubs, the degree of freezing depends on the climatic conditions, as well as the place of growth. In conditions of medium latitude, only the lower part of the shoots becomes woody in them, and this does not affect the plant's bloom in any way. The Tibetan form of the yellow peony (*R. lutea*) is frost-resistant and can winter without shelter. The biological classification of *Paeonia* L. is given in table 1 [6].

Table 1

The biological classification of *Paeonia* L.

The domain	Eukaryotes (Eukaryota)
Kingdom	Green plants (Viridiplantae)
Department	Higher plants «Streptophyta»
Overclass	Angiosperm (Magnoliophyta)
Class	Eudicots or Dicotyledons (Magnoliopsida)
Row	Lomykamenetsviti (Saxifragales)
Family	Peonies (Paeoniaceae)
Genus	Peony (<i>Paeonia</i>)

The latin name first appears in the ancient Greek philosopher Theophrastus. According to the modern classification of the American Peony Society, five groups of the *Paeonia* L. genus are distinguished.:

I – Lactiflora Gp. (created on the basis of – *P. Lactiflora*);

II – Herbaceous Hybrid Gp. (created on the basis of herbaceous species – *P. lactiflora*, *P. officinalis*, *P. peregrina*, *P. tenuifolia*, *P. mlokosewitschii*, *P. wittmanniana*);

III – Suffruticosa Gp. (created on the basis of a bush species – *P. Suffruticosa*);

IV – Lutea Hybrid Gp. (created on the basis of *P. Lutea* (subshrub) and *P. suffruticosa* (shrub));

V – Itoh Group (varieties created as a result of crossing different life forms (grassy, semi-shrubby, shrubby) (рис.2) [5-6].



I – Lactiflora Gp



II – Herbaceous Hybrid Gp.



III – Suffruticosa Gp



IV – Lutea Hybrid Gp.



V – Itoh Group

Fig. 2. Groups of the genus *Paeonia* L. depending on the modern classification of the American Peony Society

Starting in 1948, the Japanese breeder Toichi Ito began breeding work on interspecific hybridization of cultivars of herbaceous species with semi-shrub species. Ito peonies are characterized by plants with simple, semi-double and double (filled) flowers. A number of breeding works of Ito peonies are associated with outstanding figures of botanical science, in particular Louis Smirnov ('Yellow Crown', 'Yellow Dream', 'Yellow Emperor', 'Yellow Heaven', 1974), Don Hollingsworth ('Border Charm', 'Garden Treasure' 1980), Bill Seidl ('Thunderbolt', 'White Emperor', 'Yellow Emperor', 1989), Roger Anderson and David Rieth ('Martha W', 'Golden

Era', 'Bartzella', 'Cora Louise', 'First Arrival', 'Luxuriant', 'Little Darlin', 'Greta May', 1980-1990), by Wolfgang Giessler ('Yes We Can', 'German Medusa', 1999 .), Irena Tolomeo ('Golden Era', 'Boreas', 'Sonoma', 2010) and Don Smith ('Reverse Magic', 'Impossible Dream' 'Smith Opus 1 (MISAKA)', Smith Opus 2 (TAKARA)', 2016) [4-6]. To date, about 150 Itoh Group varieties are registered in the American Peony Association.

Breeding work of cultivars is actively continued until now. Modern breeding work of peonies is aimed at obtaining varieties with non-terry flowers of cream-yellow, coral-pink, lavender-pink, red, dark red, dark purple colors. Representatives of the genus *Paeonia* L. are often used in modern landscape design in the landscaping of homesteads and public places. However, *Paeonia Lactiflora* L. is mainly used in the green construction of the Podillia area, unfortunately, due to the lack of scientifically based literature on ecological and biological features, introduction, reproductive capacity and options for their use, it remains rare [6, 8, 11]. The study of these issues in the conditions of Vinnytsia, as well as the establishment of decorative, morphometric and biological features, should be studied at the scientific level with further study of prospects and replenishment of the assortment with new cultivars on the territory of our state.

From the beginning of the 19th century, the fascinating history of peonies breeding begins. French and English breeders paid special attention to peonies. After World War I, peony breeding moved to the USA along with interspecific hybridization (Halda, 2004). *Paeonia lactiflora* Pall is the most common in the world ornamental horticulture, there are about 5000 varieties in the world (Jakubowski, 2008). All varieties of *Paeonia lactiflora* Pall of Ukrainian selection are perennials, but they differ in size and shape, color, structure of flowers, duration of flowering, etc. [].

It is the enrichment of varietal diversity of the decorative species *Paeonia* L. selection, the expansion of options for simple and complex garden compositions with their participation, their more uniform placement within the boundaries of settlements, that will significantly bring the design of populated cities of Ukraine to the level of the best world models. The formation and development of breeding research at the National Academy of Sciences is associated with Academician Mykola Mykolayovych Hryshko, since the assortment of flower and ornamental plants was very poor at that time. Unique collections of flower and ornamental plants collected in the department of floriculture from different botanical and geographical regions of the world became the basis for the creation of new

varieties and hybrids that were introduced to different countries of the world, in particular, they are valuable components of the collection fund of the National Botanical Garden named after M. M. Hryshka of the National Academy of Sciences of Ukraine (NBS) [1].

Peony breeding in Ukraine was started by flower scientists A.A. Sosnovets and I.S. Krasnova in 1950. Today, the Kyiv Botanical Garden named after Grishka Breeder scientist V. F. Horobets created many varieties: Red Velvet, Red Sails, Cheburashka, Mriya, Lybid, Ophelia, Kyiv Jubilee, Skarbnytsia and many others, which are the basis for folk breeding. Taking into account the high decorative properties of the studied varieties and the great possibilities of their application, these plants are of great interest for landscaping our country and replenishing the assortment of flower and decorative crops.

Introduction of the *Paeonia* L. genus and evaluation of its success

The genus *Paeonia* L. isolated from the family *Ranunculaceae* Juss. in the independent family *Paeoniaceae* Rudolphi, has 33 species, distributed mainly in Europe, the Mediterranean, East and Southeast Asia. There are about 35 species of peonies, distributed mainly in the temperate regions of Europe, East Asia and Northwest America (Fig. 3), which are divided into 6609 varieties. In Ukraine, 2 herbaceous species grow naturally: narrow-leaved peony (*Paeonia tenuifolia*, otherwise - thin-leaved peony; folk name - Voronets), found in the forest-steppe, steppe and Crimea, and Crimean peony (*Paeonia daurica*) - Crimean endemic [4].

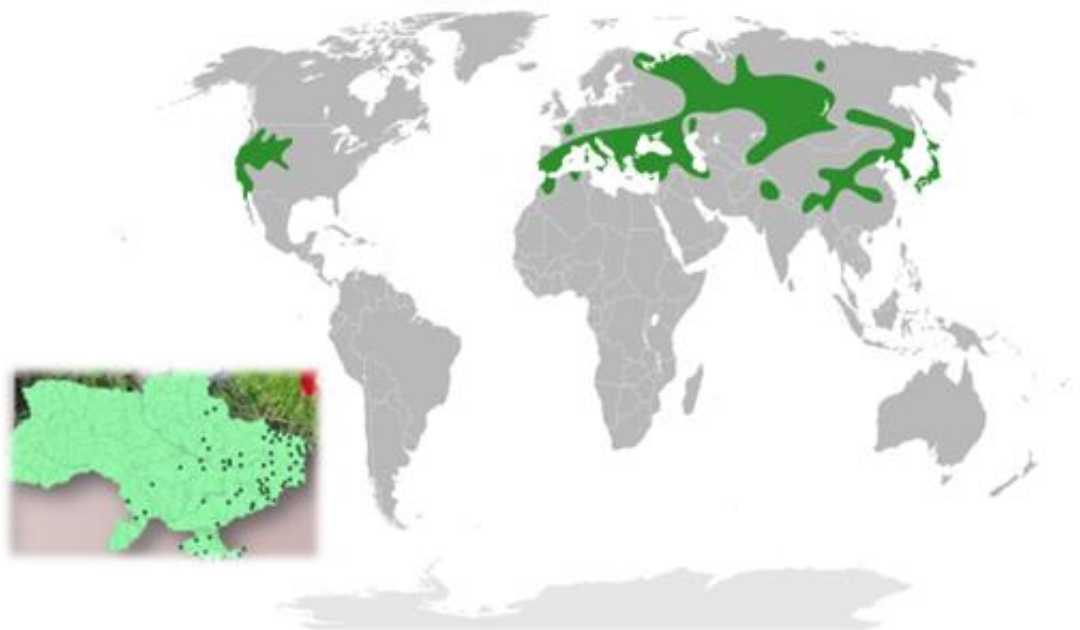


Fig. 3. The range of the greatest distribution of aboriginal species of peony

Only two species grow in the western states of North America. The most primitive representatives of the genus are concentrated in East Asia, especially in Southwest China in the mountain forests of the subtropical part at an altitude of 2360-4250 m. There are 16 species of peonies in the Flora of the USSR, and up to 12 species of peonies grow in the flora of Ukraine. In the natural conditions of the Podillia zone, 3 species are most widespread - *P. anomala*, *P. hybrida*, *P. lactiflora* [6].

The family Paeoniaceae is monotypic, includes only one genus *Paeonia*, which is a relict of the ancient mesophilic flora. Species of the genus *Paeonia* are concentrated in limited areas, are rare, some are found singly. Until now, there is no consensus among taxonomists about the allocation of peonies to an independent family, but most researchers tend to consider peonies as an independent group of plants that can be reduced to the family *Paeoniaceae Rudalphi* [4, 8].

From the beginning of the 19th century, a stormy history in the selection of peonies begins. The peony received special attention from French and English breeders. After the First World War, peony breeding moved to the USA along with interspecies hybridization [6]. *Paeonia lactiflora Pall* is the most common in world ornamental gardening, there are about 5000 varieties in the world [64, 75]. All varieties of *Paeonia lactiflora Pall* of Ukrainian selection are perennials, but they differ in size and shape, color, structure of flowers, as well as duration and intensity of flowering, etc. [8].

Both white and red forms of *Paeonia lactiflora Pall*. were grown in the gardens of China since 536. The first varieties also appear here, since breeding and growing peonies was considered a God-pleasing thing. N. Limon, D. Calot, F. Crouse, V. Lemonet, C. Verdier, A. Dessert, A. Millez are among the outstanding scientists of world-class breeders. Until now, their following varieties have not lost their popularity: *Festiva Maxima*, *Edulis Superba*, *Philomele*, *Mons. Jules Elie*, *Felix Crouse*, *Albatre*, *Le Cygne*, *Mont Blanc*, *Sarah Bernhard*, *Solange* and others, which were introduced to different countries of the world, including they are valuable components of the collection fund of the National Botanical Garden named after M.M. Hryshka of the National Academy of Sciences of Ukraine (NBS) [6].

Having analyzed the works of domestic and international scientists, such as V.G. Gorobtsia, I.M. Sokhatska, V.M. Prokopchuk, G.V. Pantsyreva, M.S. Uspenskaia, W.A. Sowling, S. Stern, R. Halda, K. Waddick, as well as a scientist breeder L.M. Kemularia-Natadze [1-4] we described the natural areas of representatives of the genus *Paeonia L.* (Table 2).

Natural areas of representatives of the genus *Paeonia* L. and indicators of minimum temperatures of their natural habitats

No	Species name	The species' natural range	The minimum temperatures, °C
1	<i>P. lactiflora</i> Pall.	China, Russia	-1,3-5,7
2	<i>P. anomala</i>	Greece, Lebanon, Syria, Italy	- 7,8-12,5
3	<i>P. hybrida</i>	Russia, Siberia	- 6,6-16,8
4	<i>P. delavayi</i> Franch	Western China	-1,3-5,7
5	<i>P. lutea</i> Delavay ex Franch	Northwest Spain, Northern Portugal	-2,9-7,6
6	<i>P. potanini</i> Kom.	the mountains of Kenya and Tanzania, southern Ethiopia	-12,7-19,8
7	<i>P. suffruticosa</i> Andr.	Canada	-4,9-12,2
8	<i>P. abchasica</i> Misch.	Caucasus, China, Japan	-12,9-17,4
9	<i>P. macrophylla</i> Lomak	USA, Canada, Ireland, Great Britain, Zealand	-3,9-12,3
10	<i>P. oreogeton</i> S. Moore.	USA, Canada	-5,7-12,3
11	<i>P. steveniana</i> Kem.-Nath.	Canada, Scotland, Sweden, Kamchatka	-15,6-30,0
12	<i>P. tomentosa</i> (Lomak) N. Busch	North America	-5,6-10,8
13	<i>P. wittmanniana</i> Hartwiss ex Lindl.	Canada, Scotland	-4,6-10,9
14	<i>P. officinalis</i> L.	Siberia, Kamchatka	-5,6-30,9
15	<i>P. brownii</i> Dougl ex Hook	Canada, Scotland, Sweden	-5,6-30,9
16	<i>P. californica</i> Nutt. ex Torn ex Grey	North America, California	-5,6-20,6
17	<i>P. arietina</i> Anders.	North America, Argentina	-4,2-30,9
18	<i>P. bakeri</i> Lynch.	Southern and Central Europe	-15,6-20,9
19	<i>P. banatica</i> Rochel ex Salm.- Dyck.	North America	-5,6-30,9
20	<i>P. broteri</i> Boiss et Rent.	China, Japan	-5,6-10,9
21	<i>P. cambessedesii</i> Willk.	North America	-5,6-30,9

22	<i>P. caucasica</i> N. Schip.	North America	-5,6-30,9
23	<i>P. clusii</i> F.C. Stern DS.	The Far East, China, Japan	-5,6-20,1
24	<i>P. coriacea</i> Boiss. Elench	the mountains of Kenya and Tanzania	-12,7-19,8
25	<i>P. decora</i> Anders	North America	-5,6-30,9
26	<i>P. emodii</i> Wall.	North America	-5,6-30,9
27	<i>P. humilis</i> Retz.	North America	-5,6-30,9
28	<i>P. japonica</i> Miyabe et Takeda	Europe, China, Japan	-5,6-30,9
29	<i>P. anomala</i> L.	steppe regions of the Caucasus, Southern and Central Europe, China and Siberia.	-11,7-29,8
30	<i>P. hybrida</i> Pall.	Southern and Central Europe, China and Siberia.	-5,6-20,1
31	<i>P. triternata</i> Pall. Ex	North America	-5,6-30,9
32	<i>P. taurica</i> Anders.	The Far East, China, Japan	-4,6-10,9
33	<i>P. tenuifolia</i> L.	North America	-5,6-30,9
34	<i>P. rhodia</i> Witt-Stern.	Canada, Scotland, Kamchatka	-5,6-30,1
35	<i>P. paradoxa</i> Anders	North America	-5,6-30,9
36	<i>P. ruprhechtiana</i> Kem.-Nath.	North America	-5,6-30,9
37	<i>P. kesrouanensis</i> Thiebaut	Asia Minor, the south of Europe, the Far East, China, Japan	-15,6-32,9
38	<i>P. lagodechiana</i> Kem.-Nath.	the mountain forests of the Caucasus	-5,6-30,9
39	<i>P. mairei</i> Leveille	North America	-5,6-30,9
40	<i>P. mascula</i> Mill.	Asia Minor, the south of Europe, the Far East, China, Japan	-15,6-32,9
41	<i>P. obovata</i> Maxim.	China, Japan	-15,6-22,9
42	<i>P. oxypetala</i> Handel-Mazzetti	The Far East, China, Japan	-4,6-10,9

Note: The information is given for the genus, the species of which are used in ornamental horticulture

According to literary sources, all types of peonies were brought to this continent by the first settlers from America. From the little experience of growing decorative plants of this genus, the vast majority of them in the conditions of European countries, as well as the USA and Canada are able to develop well, tolerate the cold period of the year, bloom and bear fruit. However, today the question of the characteristics of the above-mentioned species remains insufficiently studied.

Bio-morphological features (structure of the flower) of representatives of the genus *Paeonia* L.

Peony is a perennial herbaceous or woody plant. Its aerial part consists of a large number of stems with large leaves and flowers. This part of herbaceous representatives dies off annually. There are three types of peony roots: storage, accessory and suction.

Storage - thick brown root tubers, they contain a supply of nutrients. They are formed due to the thickening of additional roots that grow on the rhizome near the regeneration buds. The most important part of the peony root system, which provides the entire plant with water and nutrients, is the suction roots. It is easy to distinguish them - they are very small, white, die off annually [19, 20, 80].

The roots of peonies can go deep up to one meter, but they master only a loose, soft substrate. Having reached solid soil, the root system begins to grow to the sides, being located in the upper loose layer. Two or three, rarely five recovery buds sprout on each peony stem, and most remain dormant. But they germinate when the rhizomes are damaged and divided. Bud growth occurs after flowering, in July, due to nutrients produced by the leaves of flowering shoots [22, 38, 80].

Peonies are classified by the color of the stem, although it, like the color of the leaves, changes three times per season. Spring shoots in most varieties are painted in reddish tones. The anthocyanin pigment adds color to them, which allows plants to tolerate low spring temperatures. In the summer, the stems gradually acquire a characteristic variety of color, and by autumn it becomes more intense [28 – 30, 80].

Leaves in peonies are usually alternate, large, twice or thrice pinnately dissected. Under the flowers, the leaves are usually smaller and more crowded, gradually turning into sepals. There are two main types of peony leaves: in *P. suffruticosa*, *P. lutea*, and *P. delavayi* they are complex, in all herbaceous species they are simple, and the degree of dissection of the leaf plate can vary [36, 37, 51].

In some species, the leaves are twice and three times dissected with whole segments (a group of yellow-flowered species, etc.); in *P. lactiflora* - also twice tripartite; in *P. anomala* – pinnate three times; in *P. tenuifolia* - dissected many times. It is not by chance that the shape of the leaf segments is one of the main systematic features. The leaves are alternate [39, 40, 43, 47, 51]. The color of the leaves during the growth period is brown-red, of various shades, and only some have green. During the flowering of plants and later, the color of the leaves becomes green, of various shades, sometimes with anthocyanin staining of petioles and veins [41, 42, 44].

Flowers in most species are single, regular (actinomorphic), located at the end of generative shoots (terminal) (Fig. 4). The flower formula (simple form) is $*Ca5Co5A\infty G2-5$. In *P. lutea*, *P. delavayi*, *P. lactiflora*, several flowers are on each shoot [35].

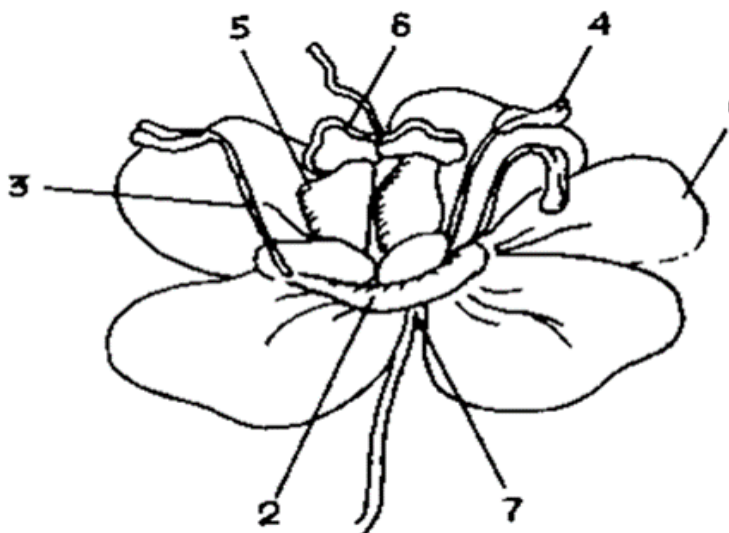


Fig. 4. The structure of a peony flower. 1 – petal of bract; 2 – the flower's disk; 3 – staminal filament; 4 – staminal anther; 5 – pistil; 6 – stigma of pistil; 7 – calyxes with sepals

The flowers are acyclic (an acyclic flower is a flower, all parts of which (perianth, stamens, pistils) are arranged in a spiral). Perianth - with a separate cup and corolla ((8-) 10-15 (-20)). Calyx ((3-) 5 (-7)) – multi-layered, leathery, consisting of 5 dark green or reddish sepals. Corolla (5-8 (-13)) – multi-petalled; petals overlap each other; white, or red, or purple. Petals sessile (rounded) [38, 81]. Androecium: stamens in most species are numerous (from 300 to 500), with thin, long filaments of various colors. The gynoecium consists of free carpels (apocarpous). The number of carpels varies (often 5 or more), some species have 2 or even 1. Many species differ in the shape and pubescence of the ovary: in some it is bare, in others it is densely pubescent; the color of stamens and pistils also varies [24, 25, 31].

In most herbaceous peonies, the flowers are red, in the Caucasian species they are whitish-yellow (with the exception of *Paeonia daurica* subsp. *mlokosewitschii*), in which they are bright yellow, and in the semi-shrub *P. Yellow* (*P. lutea*) they are also yellow. The color of the tree peony flower is interesting, where, unlike other species, there is a fuchsia spot at the base of the petals. The duration of flowering of peonies, depending on the variety, is from 8 to 16 days, and for representatives with side buds - from 18 to 22-25 days. In non-terry varieties, one flower can bloom for 6-10 days, in terry varieties - 15-18 days [18, 22]. According to the structure of the flower, peony varieties are divided into non-terry, semi-terry, terry, anemone-like, Japanese (Fig. 5) [47, 48].

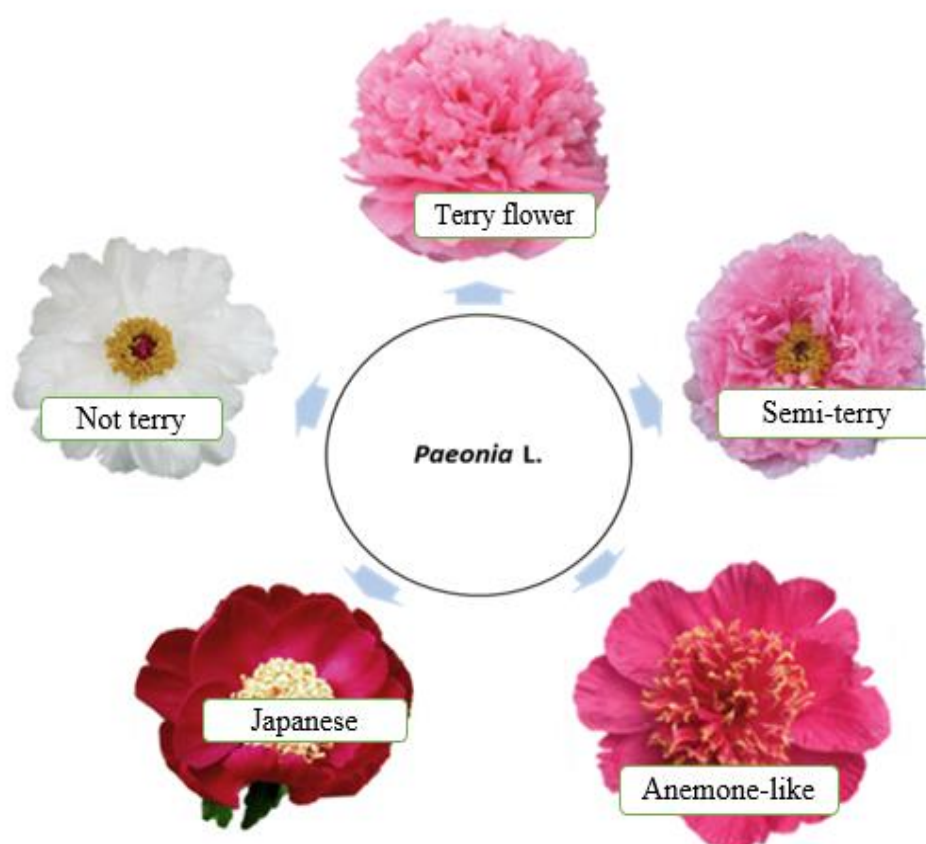


Fig. 5. Classification of peony varieties by flower structure

Non-terry peonies, the flower of which has 5-10 petals, which are arranged in 1-2 rows, in the center - pistils surrounded by stamens. Plants of this group are strong, with straight stems. Semi-double flowers are flowers with five or more petals, in the center - stamens of a modified shape, located in a ring, alternating with wide petal-shaped and normally developed stamens. Peonies of this group are light, lush. They stand for a long time in

a cut form. Terry - the flower has five or more wide outer petals, which are located around the center of the flower. In many varieties of this group, stamens and pistils are modified into petals. There are varieties in which stamens and pistils are developed normally, but are hidden by petals. Peonies of this group are also divided into subgroups depending on the shape of the inflorescence. Anemone-like - the flower has five or more petals, which are arranged in two or more rows. The stamens are modified, filling the center of the flower. Japanese is a transitional type from a simple flower to a double flower. Stamens are modified, petal-shaped, sometimes bent inward and forming a pillow. The color of the stamens is yellow, pink, red, matching the color of the petals or contrasting. The stems of plants of this group are straight and strong [47, 65, 67].

The peculiarity of herbaceous peonies is that they are geophytes, that is, they belong to the group of plants that hide their regeneration buds underground. Therefore, after the end of vegetation, their above-ground shoots dry up, that is, they behave like annuals, and the thickened stolons sink underground, becoming perennial shoots there. They smoothly transition into rhizomes, on which the recovery buds develop. Almost all herbaceous peonies have elongated rhizomes, only about 1-2 cm thick and 6 to 12 cm long. They live their own rather interesting lives. In the process of vegetation, additional roots grow on the rhizomes, the basal part (the area near the base) of which gradually thickens, turning into tubers or cones. So-called absorbent roots appear at their ends. Every autumn, peonies retract the basal parts of the shoots, thereby providing protection for the vegetative buds in the cold [69, 80, 81]. Peony - can grow in one place for ten years. Its stem reaches a height of 1-2 m, and the bud itself can be up to 25 cm in diameter. The flower is unpretentious in care, has a large rhizome and lush leaves, which can be from green to dark purple [50].

Primary introductory studies are aimed at determining the possibilities of adaptation of plants to new environmental conditions and identifying methods of this adaptation. In different conditions of the seasonal climate, this is reflected in the rhythm of biological processes, the change of phenological phases. The analysis of long-term phenological observations allows establishing the timeliness of the beginning and end of vegetation, flowering and fruiting of introduced species to new growth conditions. When studying the adaptive capabilities of a species in culture, it is prospective to compare the morphobiological features of plants in new growing conditions with local species, as well as to conduct a comparative analysis with already successfully introduced representatives of the genus,

close in biological features and economic characteristics. Such an analysis allows us to draw a conclusion about how close the studied features of the introducers are to the native species, as well as how far the new growth conditions hinder or promote the formation of economically valuable organs and plant features [20]. In our studies and observations of varieties / hybrids of peonies as decorative plants, the following phenological phases were noted: - germination, - active vegetation, - budding, - flowering, - fruit setting, - fruit ripening, - the end of vegetation (Fig. 6).



germination



active vegetation



budding



flowering



fruit setting



fruit ripening

Fig. 6. Phenological observations of the phases of growth and development of the studied peony varieties/hybrids

Selection work in Ukraine and around the world. Variety study of representatives of the *Paeonia* L. genus.

According to scientists, the following types of peonies are recommended for the territory of Ukraine as decorative plants: *P. anomala*, *P. delavayi*, *P. emodii*, *P. humilis*, *P. japonica*, *P. lactiflora*, *P. lutea*, *P. macrophylla*, *P. mascula*, *P. miokosewitschii*, *P. obovata*, *P. oreogeton*, *P. officinalis*, *P. peregrina*, *P. potanini*, *P. suffruticosa*, *P. steveniana*, *P. taurica*, *P. tenuifolia*, *P. tomentosa*, *P. triternata*, *P. veitchii*, *P. wittmanniana* [8, 20].

The International Register (APS) describes 4,664 varieties of herbaceous peonies and more than 500 tree peonies. The total number of varieties, including domestic ones, is about 6,000 [17-20].

It is the enrichment of varietal diversity of the decorative species *Paeonia* L. selection, the expansion of options for simple and complex garden compositions with their participation, and their more even placement within the boundaries of settlements, that will significantly bring the design of populated cities of Ukraine closer to the level of the best world examples [16, 37-44].

The establishment and development of breeding research in the national botanic garden is associated with Academician Mykola Mykolayovych Hryshko, since the assortment of flower and ornamental plants at that time was very poor. The unique collections of flower and ornamental plants collected in the department of floriculture from different botanical and geographical regions of the world became the basis for the creation of new varieties and hybrids that were introduced to different countries of the world, including they are valuable components of the collection fund of the National Botanical Garden named after M.M. Hryshka of the National Academy of Sciences of Ukraine (NBS) [9, 22, 30-36].

Peony breeding in Ukraine was started in 1950 by flower scientists A.A. Sosnovets and I.S. Krasnova. Today, in our country, the Kyiv Botanical Garden named after Hryshka conducts a large breeding work. Breeder scientist V. F. Horobets created many varieties: Red Velvet, Red Sails, Cheburashka, Mriya, Lybid, Ophelia, Jubilee of Kyiv, Skarbnysia and many others, which are the basis for folk breeding [10, 21].

After analyzing the State Register of varieties of *Paeonia* L., it was established that the selection work on creating new peony varieties in Ukraine is still at an insufficient level. The range of *Paeonia* L. species in Ukraine currently includes 42 varieties and hybrids [13, 21, 50-54, 67-68].

The registration of varieties of the researched species of peony in Ukraine was carried out for 25 years. It was established that from 2003 to 2012, no varieties suitable for distribution were registered in the State Register of *Paeonia* L. varieties. Breeding work on creating new varieties of peonies resumed in 2013 [14-15, 21, 45, 60-66].

According to the State Register of Plant Varieties of Ukraine, the following varieties and hybrids of peonies are available: Yasochka, Kyiv Jubilee, Milky Way, Red Tower, Champion, Charivnyk, Sorcerer, Red Sails, Red Velvet, Khokhloma, Favorite, Svitlana, Svitoch, Skrabnytsia, Pysanka of Kolomyia, Ophelia, Butterfly, Raspberry fire, Dream, Lantern, Swan, Kobzar, Corypheus, Quasimodo, Iroquois, Placer of pearls, Ducat, Hercules, Wedding, Benefit, Bereginya, Anteus, Spring defile, Dawn poem, Zoryana, Cheburashka, Coquette, Heroes of the heavenly hundred, May dews, Blondin, Chornomor, Firefly (Table 3) [12, 15, 21-22].

Table 3

***Paeonia* L. varieties included in the State Register of plant varieties suitable for distribution in Ukraine in 2022**

№	Variety (hybrid)	Recommended growing area	Using	Registration year
1	Yasochka	Forest-steppe, Polissia	Ornamental and Healing	1997
2	Kyiv Jubilee		Ornamental and Healing	2003
3	The Milky Way		Ornamental and Healing	2009
4	The Red Tower		Ornamental and Healing	2008
5	Champion		Ornamental and Healing	2008
6	Magician	Forest Steppe, Polissia, Steppe	Ornamental and Healing	2008
7	Sorceress		Ornamental and Healing	2003
8	The red sails	Forest-steppe, Polissia	Ornamental and Healing	2000
9	Red velvet	Forest-steppe, Polissia	Ornamental and Healing	1993
10	Hokhloma	Forest-steppe, Polissia	Ornamental and Healing	1993

11	The favorite		Ornamental and Healing	2008
12	Svitlana	Forest Steppe, Polissia, Steppe	Ornamental and Healing	2008
13	Svetoch	Forest-steppe, Polissia	Ornamental and Healing	1994
14	The treasury	Forest-steppe, Polissia	Ornamental and Healing	1998
15	Pysanka of Kolomyia	Forest-steppe, Polissia	Ornamental and Healing	2009
16	Ophelia		Ornamental and Healing	2000
17	Butterfly		Ornamental and Healing	2008
18	Malynova Vatra		Ornamental and Healing	2009
19	The dream	Forest-steppe, Polissia	Ornamental and Healing	1997
20	Flashlight	Forest Steppe, Polissia, Steppe	Ornamental and Healing	2008
21	Lybid	Forest-steppe, Polissia	Ornamental and Healing	1997
22	Kobzar	Forest Steppe, Polissia, Steppe	Ornamental and Healing	2008
23	Corypheus		Ornamental and Healing	2003
24	Quasimodo		Ornamental and Healing	2009
25	Iroquois	Forest Steppe, Polissia, Steppe	Ornamental and Healing	2008
26	Pearl placer	Forest-steppe, Polissia	Ornamental and Healing	1994
27	Ducat	Forest-steppe, Polissia	Ornamental and Healing	1997
28	Hercules		Ornamental and Healing	2009
29	Bridal	Forest-steppe, Polissia	Ornamental and Healing	1997

30	Benefit performance		Ornamental and Healing	2003
31	Berehynia	Forest-steppe, Polissia	Ornamental and Healing	1997
32	Antaeus	Forest-steppe, Polissia	Ornamental and Healing	1999
33	Spring defile	Forest-steppe, Polissia	Ornamental	2016
34	Dawn poem	Forest-steppe, Polissia	Ornamental	2013
35	Starlit	Forest-steppe, Polissia	Ornamental	2013
36	Cheburashka	Forest-steppe, Polissia	Ornamental	2013
37	Coquette	Forest-steppe, Polissia	Ornamental	2013
38	To the heroes of the heavenly hundred	Forest-steppe, Polissia	Ornamental	2016
39	May dews	Forest-steppe, Polissia	Ornamental	2016
40	Chornomor	Forest-steppe, Polissia	Ornamental	2016
41	A blond	Forest-steppe, Polissia	Ornamental	2016
42	The firefly	Forest-steppe, Polissia	Ornamental	2016

The main areas of use of varieties and hybrids of *Paeonia* L. are decorative (landscape, cut) and medicinal. The plant is cultivated, as a rule, in flower gardens and gardens as a decorative plant, and in folk medicine, in addition to flowers, peony rhizomes are used [1-8, 16, 21, 60].

All varieties of *Paeonia lactiflora* Pall of the Ukrainian selection are perennials, but they differ in size and shape, color, flower structure, duration of flowering, etc. It is the enrichment of varietal diversity of the decorative species *Paeonia* L. selection, the expansion of options for simple and complex garden compositions with their participation, their more uniform placement within the boundaries of settlements, that will significantly bring

the design of populated cities of Ukraine closer to the level of the best world examples [22, 40-54, 69-72].

In the field of horticulture, the genus *Paeonia* L. is represented by both a significant number of species (40) and a rich varietal assortment, amounting to more than 6,000 varieties. At the same time, it was found that the assortment of decorative crops of Ukraine includes 5 species, that is, less than 2% of varieties. From a practical point of view, all studied varieties and hybrids of Ukrainian selection are of interest as potentially valuable objects for enriching the assortment of ornamental plants of Ukraine and are promising for creating a monogarden on the basis of the Vinnytsia National Agrarian University.

The development of measures regarding the functionality of peony plantations and the improvement of their decorative and aesthetic qualities, the creation of architectural and planning models of flower gardens of various functional purposes was carried out on the basis of scientific research, developments and generalizations of the experience of Ukrainian and foreign practitioners and scientists.

Table 4

General characteristics of the studied representatives of *Paeonia* L.

No	Name	Brief characteristics
1	China Maid	A hybrid of a milk-flowered peony. Anemone-shaped. Perennial herbaceous plants 90-100 cm in height. The flowers are 19-20 cm in diameter.
2	Magician	Flower color - white. The bush is tall, beautiful in shape. The height of the bush is 80 cm.
3	Heritage	The color of the flower is red, outside with a brown shade, h-100.
4	Triumph de Nord	Pink terry flower of a rose-shaped shape, large (up to 18 cm)
5	Corypheus	The flower is bright red, the bush is compact.
6	Malynova Vatra	The flower color is bright crimson, the bush is compact and decorative.
7	Antaeus	Dark crimson color of the flower, decorative bush.
8	Mahogany	The color of the flower is dark red-chestnut, towards the center is red, h-80
9	Diana Parks	The flower color is bright red with an orange tint, very beautiful, interspecies hybrids.
10	Cherry Red	The flower color is pure dark red, shiny.
11	Venus	The outer petals are large, forming a pale pink bowl with a lilac tint

12	Sarah Bernard	The color of the flower is pink-lilac with lighter edges, one of the best of this color, an unsurpassed favorite, a delicate spectrum of smell.
13	Reine Hortense	Bright dark pink flowers, dark leaves and strong red stems.
14	The red sails	The flower is blood-red in 2-3 rows, with bright yellow stamens in the center. Universal. Bush height 100 cm.
15	Svitoch	The color is bright crimson-lilac, large petals, beautiful shape, h - 90 cm.
16	Flashlight	The color is bright crimson-lilac, large petals, beautiful shape, h - 90 cm.
17	Scattered pearls	The flower is tender, light, very beautiful. Petals are light pink, staminodia yellowish-pink. Height 70-80 cm. Universal.
18	Henry Bockstoce	The color of the flower is blood red with a shine, a prize winner of exhibitions, an interspecies hybrid.
19	Mons. Jules Elie	The color of the flower is light pinkish-lilac with silvery tips, a delicate aroma.
20	Seraphim	The color of the flower is white with a pink tint, h-60, very early.
21	Red velvet	The color of the flower is dark red (burgundy), a decorative bush.
22	Rubra plena	The presence of purple, dark cherry or ruby-red inflorescences with a diameter of about 15 cm with shiny petals.
23	Tenuifolia plena	Herbaceous. Intraspecific variety from p. tenuifolia. Terry The color of the flower is bright red, shiny. The bush is semi-spreading. The leaves are narrowly dissected.
24	Steppe thin-leaved	Very early flowering period. The smell is weak.
25	Doreen	Pink with yellow staminodes
26	Gay Paree	The color of the flower is dark pinkish-red, the center is made of narrow cream-colored petals with a red reflection inside. Compact, very decorative. The height is 100 cm.
27	Gold Standart	The color of the flower is white, the staminodia are cream with a yellow tint.
28	Hit Parade	Double-row, bright pink, staminodia with golden tips. The height of the bush is 80 cm.
29	Moon of	White-green color, staminodia light yellow, h - 90 cm.

	Nippon	
30	Neon	The color of the flower is rich pink-lilac, the petals are wide, the staminodia are large pink with a yellow edge, original.
31	Philomele	Diameter of the flower: 16. Height: 90. Flowering period: early. The smell: pleasant.
32	Hot Chocolate	A flower with 2-3 rows of petals, dark burgundy, in the center a ball of staminodia of the same color, slightly edged with gold. The light flower is raised high above the bush. The height of the bush is 80 cm. Universal.

The object of the study was morphometric indicators, some phenological aspects, biology of peonies development, duration of flowering, different varietal groups. When conducting phenological observations, the main phenophases, their calendar terms and duration were recorded. Morphometric indicators were used to study morphological features of growth and development. The totality of the obtained data provides an opportunity and information for their practical application in decorative gardening with the participation of *Paeonia* L. and determination of the place and role of peonies as factors of enrichment of the assortment and improvement of the quality of mass and individual gardening.

According to the research results, the main morphometric parameters of the species and varieties of *Paeonia* L. were determined (Table 5).

Table 5

Morphometric parameters, flower color and flowering period of decorative and valuable varieties of *Paeonia* L.

№	Variety (hybrid)	The shape of the flower	The term of flowering	The size of the flower	The presence of aroma	The color of the flower	Using
1	China Maid	Japanese	Mid-late	20	Aromatic	Light pink	To cut flowers
2	Magician	Terry spherical	Medium	18	The aroma of lily of the valley	White	Monosads
3	Heritage	Terry rosiform or semi-terry	The early	Up to 18 cm	Aromatic	Red	Can be used as a solitaire
4	Triumphe du Nord	Terry flower	Late	Up to 18 cm	Aromatic	Pink	To cut flowers

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5	Corypheus	Terry flower	The early	Up to 20 cm	Weak aroma	Red	Mixborder
6	Raspberry bonfire	Terry flower	Medium	Up to 18 cm	Aromatic	Carmine-red	The second plan of flower gardens
7	Anteus	Terry rosiform	Medium	Up to 16 cm	Weak aroma	Raspberry red	A group, an array
8	Mahogany	Simple	Early-middle	Up to 18 cm	Aromatic	Red	A group, an array
9	Diana Parks	Terry rosiform	Early-middle	Up to 14 cm	Aromatic	Blood-red	Mixborder, rabatka
10	Cherry Red	Terry rosiform	The early	20	Aromatic	Red	Can be used as a solitaire
11	Venus	Terry crown shaped	Medium	Up to 18 cm	Weak aroma	Pink	Solitaire, Mixborder
12	Sarah Bernard	Semi-terry	Medium-late	Up to 20 cm	Strong aroma	Light pink	Solitaire, to cut flowers
13	Reine Hortense	Terry flower	Medium	Up to 17 cm	Weak aroma	Pink	To cut flowers
14	The red sails	Simple	Early-middle	Up to 15 cm	Weak aroma	Red	To cut flowers
15	Svitoch	Terry flower	Medium-late	Up to 16 cm	Weak aroma	Red, Pink	Front gardener
16	Flashlight	Terry flower	The early	Up to 17 cm	Weak aroma	Raspberry red	Front gardener
17	Scattered pearls	Japanese	The early	Up to 16 cm	Aromatic	Pink	A group, an array
18	Henry Bockstoe	Terry flower	Early-middle	Up to 20 cm	Weak aroma	Blood-red	Can be used as a solitaire
19	Mons. Jules Elie	Terry flower	The early	18-20	Not too strong a scent	Pink	Solitaires, groups, arrays
20	Seraphim	Simple	Very early	Up to 15 cm	Aromatic	White	Floral compositions
21	Red velvet	Semi-terry	The early	Up to 15 cm	Weak aroma	Deep red	Monosads
22	of. Rubra plena	Terry hemisph	The early	Up to 14 cm	Weak aroma	Red	Front gardener,

		erical					solitaire, mixborder
23	Tenifolia plena	Terry flower	The early	10	Weak aroma	Red	Rockeries, mixed flower beds
24	Steppe thin- leaved	Not terry	The early	10	Weak aroma	Blood -red	Rockeries, mixed flower beds
25	Doreen	Japanese	Medium	16	Aromatic	Pink, Stami nodia are yellow	Can be used as a solitaire
26	Gay Patee	Japanese	Medium- late	Up to 13 cm	Aromatic	Pink	Can be used as a solitaire
27	Gold Standart	Japanese	Medium	Up to 15 cm	Weak aroma	White	Flowerbeds of continuous flowering
28	Hit Parade	Japanese	Medium	Up to 14 cm	Aromatic	Pink	Mixborders , arrays, groups
29	Moon of Nippon	Japanese	Medium- late	16	Aromatic	White and green	To cut flowers, mix border, monosads
30	Neon	Japanese	Late	Up to 16 cm	Aromatic	Pink	To cut flowers
31	Philomele	Terry crown shaped	The early	Up to 12 cm	Weak aroma	Pink	Mixborder
32	Hot Chocolate	Japanese	Medium	16	Aromatic	Deep red	To cut flowers, groups

All studied species belong to groups with very early, early, early-medium, medium, medium-late and late flowering periods. Available flowers with both weak and strong aroma. They are used for bouquets, flower gardens, monogardens, floral compositions and as medicinal plants. The color of the flowers varies from white to dark red. The form is from simple non-terry to terry. Specimens of peonies, which are presented at the exposition site of VNAU, can ensure continuous flowering, as they belong to different groups (table 6).

Table 6

Flowering spectrum of peonies *Paeonia* L.

№	Name of variety (species)	The color of the flower								
		May			June			July		
		1	2	3	1	2	3	1	2	3
1	China Maid									
2	Magician									
3	Heritage									
4	Triomphe du Nord									
5	Corypheus									
6	Raspberry bonfire									
7	Anteus									
8	Mahogany									
9	Diana Parks									
10	Cherry Red									
11	Venus									
12	Sarah Bernard									
13	Reine Hortense									
14	The red sails									
15	Svitoch									
16	Flashlight									
17	Scattered pearls									
18	Henry Bockstoce									
19	Mons. Jules Elie									
20	Seraphim									
21	Red velvet									
22	of. Rubra plena									
23	Tenifolia plena									
24	Steppe thin-leaved									
25	Doreen									
26	Gay Paree									
27	Gold Standart									
28	Hit Parade									
29	Moon of Nippon									
30	Neon									
31	Philomele									
32	Hot Chocolate									

The spectrum of flowering of the studied species of peonies consists of white and various shades of red and pink, which creates a saturated color gamut and is highly decorative and promising for cultivation in the

conditions of the architectural and exposition site of VNAU.

The assortment of the genus *Paeonia* L. on the exposition site is presented in the form of 32 species, varieties and hybrids, including such well-known varieties of Ukrainian breeding as 'Corypheus', 'Raspberry bonfire', 'Anteus', etc., the originator of which is V. Gorobets. Among the examined specimens are species, varieties and hybrids. Representatives of the Ukrainian selection deserve special attention, which are distinguished by their endurance, resistance to pests and adverse weather conditions, as well as decorative flowers and a pleasant aroma. It is also worth highlighting varieties with a Japanese anemone-like shape, which are distinguished from others by their original type of flower.

Conclusions

In the field of horticulture, the genus *Paeonia* L. is represented by both a significant number of species (40) and a rich varietal assortment, amounting to more than 6,000 varieties. At the same time, it was found that the assortment of decorative crops of Ukraine includes 5 species, that is, less than 2% of varieties. From a practical point of view, all studied varieties and hybrids of Ukrainian selection are of interest as potentially valuable objects for enriching the assortment of decorative plants of Ukraine and are promising for creating a monogarden on the basis of Vinnytsia National Agrarian University.

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PROBLEMS AND SOLUTIONS**

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