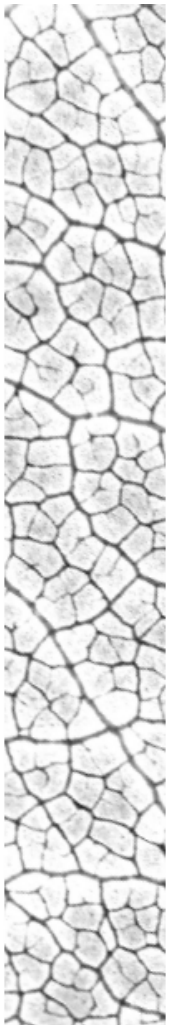

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# Collection of cover-ground plants and plants for Alpinarians and Rocarians in botanical garden of Belgorod University (Belgorod, Russia)

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**Abstract**
They provided the data on plants from the collection fund of ground cover and other ornamental herbaceous plants suitable for gardening in Belgorod Region (Russia). They determined the life forms by Raunkier and the periods of species flowering. The studied plants are distributed in relation to light and moisture content. They performed the observations of plant state in the process of cultivation. The authors studied the introduced herbaceous perennials, that were not used previously for landscaping of the region. According to the data presented in the article, recommendations can be given for gardening in various landscape areas, proceeding from the decorative and ecological properties of plants. They identified the perennial ground cover plants unpretentious to the conditions of the urban environment, which can be used in sunny areas, in shades and half-shades.

**Keywords:** stunted and groundcover herbaceous perennials, botanical garden, life forms, decorative effect

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## INTRODUCTION

Special studies are needed in order to increase biodiversity and optimize flower design with ground cover plants in different regions (Polukhin et al. 2015, Tokhtar et al. 2016). Among the large number of various landscape elements, rockeries and rock gardens are very popular, with perennial herbaceous plants taking the lead (Chub 2007, Markovsky 2007). Due to decorative flowers, leaves, comparative ease of reproduction, prolonged flowering, winter resistance, they deserve special attention in the gardening of both urban recreation areas and country sites (Kocherezhko and Kocherezhko 2003, Titchmarsh 2012).

Currently the collection of the Botanical Garden of the Belgorod State University (SRU “BelSU”) has 103 samples of plants of 94 species suitable for use in this landscape trend.

The objectives of our study included the study of ground cover and other perennial ornamental plant range suitable for landscaping the territories of the Belgorod region of Russia, for their distribution into groups depending on growing conditions.

## MATERIALS AND METHODS

The range of perennial ground cover and ornamental plants is based on the study of the Botanical Garden collection at Belgorod University. The range is systematized on the basis of literature data study about the growing conditions and the possibilities of perennial plant use for the flower decoration of cities (Sokolova et al. 2013), as well as on their own observations of the state of plants in the process of their cultivation on the collection site territory.

They provided the names of taxa in the rank of families and genera according to Takhtadzhyan (1987). The degree of species compliance with growth conditions was assessed by Zaitsev’s method (1978).

The classification of ecological types of plants by water regime is provided by Shennikov (1950).

## RESULTS AND DISCUSSION

Our studies of ornamental and ground cover plants revealed that all species growing in the collection belong to perennial ornamental plants. Most species in the system of life forms (K. Raunkier) belong to hemicryctophytes (82 species), some species belong to hamephites (16 species). These are, for example, such plants as Vinca minor, Eriophyllum lanatum, Perovskia atriplicifolia and others, the pillow plants of the genus

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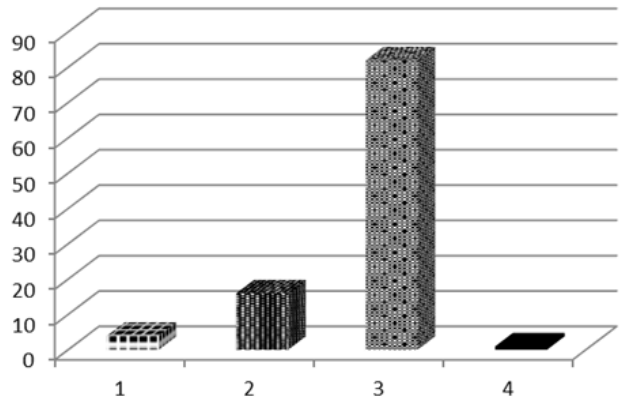



1 – geophytes; 2 – hamephytes; 3 – hemicryptophytes; 4 – phanerophytes

**Fig. 1.** Life forms of ornamental perennial plants from the Belgorod Botanical Garden collection

Sempervivum and Phlox divaricata. Bulbous plants (Allium, Scilla, Corydalis) belong to geophytes - they make the collection minority - 4 species and 1 type of Paxistima canbyi belong to phanerophytes, low-growing shrubs (**Fig. 1**).

We have carried out the ecological analysis of the life forms of plants growing in the Botanical Garden of the Belgorod University, and their flowering periods were determined for further prospective use in gardening (**Table 1**).

The dominant element of the collection is ground cover plants - the group of short-growing (often creeping) plants with the ability to capture and hold new area actively (Karpisonova and Rusinova 2005).

Most species of the collection are the plants of high alpine meadows, which grow in open spaces and are strongly affected by the sun rays. Therefore, one can find many characteristic adaptations to the existence (adaptation) conditions (Kolesnikova 2014). All plants can be divided into several groups depending on adaptive characteristics to environmental conditions.

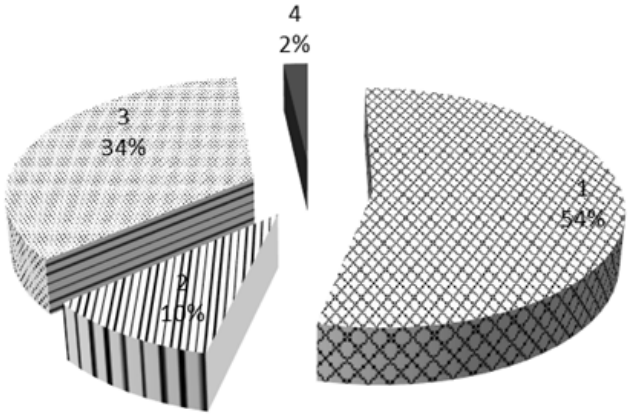
The first group of plants is characterized by leaf blade surface decrease to save moisture. These plants include: Sagina subulata (Sw.) C. Presl., Phlox subulata L., Thymus serpyllum L. Cerastium arvense L., Cerastium biebersteinii DC., Euphorbia cyparissias L. belong to the mountain plants with small leafy plates. The second group of species includes the plants with different outgrowths, hairs, and often thick, felt pubescence, which also protects leaves from excessive heating and evaporation. An example of this group is Stachys lanata Jacq. from Lamiaceae Lindl family. This unpretentious silvery-white plant with dense pubescence and small pink flowers, collected in whorls, has long been used in gardens as an ornamental one.

The third group of species includes succulent plants, which have succulent fleshy organs: leaves or stems, where moisture is stored for use in case of a hot dry period of time. Thus, succulent plants are able to exist for a long time without water and often settle on stones where the soil is almost absent. This group of plants includes the creeping opuntia cactus - Opuntia humifusa Raf. Stalk is its juicy storage body. The homeland of opuntia is the south of the United States. In the conditions of the Botanical Garden of the Belgorod University, the plant winters in the open ground without shelter. Sedum and Sempervivum (Crassulaceae DC.) with juicy leaves are grown in the mountains of Europe and Asia.

In addition to low-growing plants, other herbaceous ornamental perennials grow in the collection, which are

**Table 1.** Terms of ornamental perennial plant flowering from the collection of Belgorod Botanical Garden

| Flowering periods | Plant names |
|---|---|
| Spring-summer flowering (4-7 months) | *Alyssum repens* Baumg, *Aegopodium podagraria* L., *Sedum album* L., *Allium auctum* Omelcz. [*A. decipiens* Fisch. ex Schult. & Schult. f.], *Campanula carpatica* «Alba» Jacq., *Draba brumifolia* Steven, *Antennaria dioica* (L.) Gaertn., *Vinca minor* L., *Campanula hybrida* «Elizabeth», *Brunnera* "Jack Frost", *Vinca minor* «Multiplex» L., *Dianthus deltoides* L., *Brunnera sibirica* Steven., *Vinca minor* «Ralhp Shugert» L.,*Dianthus giganteus* d'Urv ssp. Subgiganteus, *Arabis caucasica* Schlecht, *Anthemis sosnovskyana* Fed.,*Dianthus gratianopolitanus* Vill. = *Dianthus caesius* Sm., *Iberis sempervirens* L., *Eriophyllum lanatum* (Pursh) Forbes., *Dianthus hungarikus* Pers., *Cerastium arvense* L., *Minuartia circaussica* (Albov) Woronow,*Sedum sexangulare* L., *Cerastium biebersteinii* DC., *Helianthemum appeninum* (L.) Mill, *Dianthus furcatus* Balb., *Dianthus sylvestris* Wulfen ssp. Tergestinus, *Dianthus turkestanicus* (Preobr.), Ju. Kozhevn. *Viscaria vulgaris* Bernh. *Sedum erythrostictum*''Mediovariegata'', *Corydalis solida* (L.) Clairu, *Dicentra spectabilis* (L.) Lem. Alba, *Ajuga orientalis* L., *Ajuga reptan*«Metallica crispa» L., *Ajuga reptans* "Burgundy Glow" L. , *Ajuga reptans* L., *Ajuga reptans* "Burgundy Glow" L., *Ajuga reptans "*Chocolate Chip" L., *Glechoma hederacea* L., *Stachys macrantha* (K. Koch) Stearn, *Thymus serpyllum* L., *Menispermum dahuricum* DC. *Phlox divaricata* L., *Lysimachia nummularia* L., *Scilla sibirica* Haw., *Anemone sylvestris* L., *Acaena microphylla* Hook.f., *Alchemilla vulgaris* L., *Geum x hybridum hort., Potentlla alba* L., *Potentlla aurea* L., *Potentilla nepalensis* 'Miss Willmott', *Waldsteinia ternata* (Steph.) Fritsch, *Bergenia crassifolia* (L.) Frilsch. |
| Summer-autumn flowering (7-10 months) | *Allium odorum* L.,*Liatris spicata* 'Kobold' *(L.) Willd.,Ophiopogon planiscapus* «Niger» Nakai, *Solidago hybride* «Laurin», *Sedum spectabile* Star Dust, *Hylotelephium sieboldii* (Sweet ex Hook.), *Sagina subulata* (Sw.) C.Presl., *Sedum acre* L., *Solidago Hybride* "Nana", *Sedum spectabile* "Brilliant", *Sedum telephium* ''Matrona'', *Sempervivum tectorum* L *Sedum ewersii., Solidago Hybride* Cloth of Gold, *Sedum spectabile* "Variegata", *Sempervivum ruthenicum* (W. D. J. Koch) Schnittsp. et C. B. Lehm., *Euphorbia cyparissias* L., *Sedum hispanicum* L., *Solidago hybrid* Strahlenkrone, *Sedum hybridum* L., *Sedum rupestre* L., *Sedum sediforme* (Jacg.) Pau.,*Sedum spurium* Bieb.=kamtschaticum Fisch., *Sedum subulatum* (C.A.Meyer) Boissier., *Sempervivum hybridum* "Faraon", *Geranium maculatum* «Elizabeth Ann», *Geranium phaeum* L., *Geranium pratense* L., *Mentha piperita* L., *Perovskia atriplicifolia* Benth., *Oenothera missouriensis* Sims., *Limonium scoparium* (Pall. ex Willd.) Stank., *Polygonum affine* G. Don., *Aruncus aethusifolius* 'Noble Spirit', *Potentlla crantzii* (Crantz) Beck ex Fritsch, *Veronica armena* Boiss.et Huet., *Opuntia humifusa* Raf. |
| Continuous flowering (5-10 months) | *Nepeta mussinii* Henke., *Nepeta transcaucasica* Grossh, *Prunella grandiflora* (L.) Scholl., *Stachys lanata* Jacq., *Phlox subulata* L., *Duchesnea indica* (Andr.) Focke, *Fragaria* "Lipstick" (*Fragaria ananassa* x *Potentilla palustris*), *Potentilla tridentata* "Nuuk", *Heuchera micrantha* Douglas ex Lindl. |




1 – heliophytes; 2 - heliosciophytes 3 – sciophytes; 4 – universal plants

**Fig. 2.** Classification of plants by light relation

very promising for use in various floral compositions of the region. Among such plants is Paxistima canbyi - an evergreen plant of the family Celastraceae, Perovskia atriplicifolia, the hybrid varieties Solidago, Oenothera missouriensis and the members of the family Campanulaceae.

In relation to the intensity of insolation, most species belong to heliophites (light-loving - 54%) and to helioscyophytes (shade-tolerant plants - 34%). Shade loving plants are represented by Geum x hybridum, Aruncus aethusifolius, Sagina subulata, and Vinca plants (10%). Two species of Geranium phaeum and G. prétense are universal, since they grow and bloom successfully in both shady and solar habitats (**Fig. 2**).

According to the requirement for soil moisture, various groups of plants are distinguished, from hydromesophytes to xerophytes (**Table 2**).

The compliance with the humidity regime is a necessary condition when they use these plants in various planting conditions and decorative compositions of the region.

## CONCLUSION

After the study of ornamental plant collection in the Botanical Garden of the Belgorod University, they offered the assortment of unpretentious perennial ornamental plants to landscape the territories of the Belgorod Region, and they compiled the assortment table of plants by groups. They presented the main characteristics of plants by the need for moisture and lighting. They showed the periods of their flowering. They established that some ground cover perennial flower plants are universal in the conditions of the Belgorod Region of Russia and can grow in open areas, in half-shades and even in shades.

All studied perennials of the Botanical Garden collection from the Belgorod University are winter resistant, quite drought-resistant and are reproduced well by seed and vegetative means. High decorativeness of these plants allows us to recommend them for various Belgorod region territories and to create flower beds of various trends and styles.

**Table 2.** The ratio of ornamental perennial plants to soil moisture

| Relation to moisture conditions | Series name |
|---|---|
| Mezogigrophyte | *Viscaria vulgaris Bernh., Paxistima canbyi A. Gray, Ophiopogon planiscapus «Niger» Nakai, Glechoma hederacea L., Waldsteinia ternata (Steph.) Fritsch* |
| Mezophyte | *Vinca minor* L.,*Vinca minor* «Multiplex» L.,*Vinca minor* «Ralhp Shugert» L., *Brunnera* "Jack Frost",*Brunnera sibirica* Steven., *Dianthus deltoides* L., *Dianthus turkestanicus* (Preobr.) Ju. Kozhevn., *Viscaria vulgaris* Bernh., *Sedum spurium* Bieb.=kamtschaticum Fisch., *Corydalis solida* (L.) Clairu, *Ajuga reptan* «Metallica crispa» L., *Ajuga reptans* "Burgundy Glow" L., *Ajuga reptans* L., *Ajuga reptans* "Burgundy Glow" L., *Ajuga reptans "*Chocolate Chip" L., *Stachys lanata* Jacq., *Menispermum dahuricum* DC., *Polygonum affine* G. Don, *Phlox divaricata* L., *Phlox subulata* L., *Scilla sibirica* Haw., *Acaena microphylla* Hook.f, *Alchemilla vulgaris* L., *Aruncus aethusifolius* 'Noble Spirit', *Fragaria* "Lipstick" (*Fragaria ananassa* x *Potentilla palustris*), *Potentlla aurea* L., *Potentlla crantzii* (Crantz) Beck ex Fritsch, *Potentilla nepalensis* 'Miss Willmott', *Potentilla tridentata "*Nuuk", *Bergenia crassifolia* (L.) Frilsch, *Heuchera micrantha* Douglas ex Lindl. |
| Xeromezophyte | *Aegopodium podagraria* L.,*Antennaria dioica* (L.) ,Gaertn.*Liatris spicata* 'Kobold' *(L.), Willd. Arabis caucasica* Schlecht, *Iberis sempervirens* L., *Cerastium arvense* L., *Dianthus furcatus* Balb., *Dianthus giganteus* d'Urv ssp. Subgiganteus, *Dianthus gratianopolitanus* Vill. = *Dianthus caesius* Sm, *Allium auctum,* Omelcz. [*A. decipiens,* Fisch. ex Schult. & Schult. f.],*Allium odorum* L., *Dianthus hungarikus* Pers., *Dianthus sylvestris* Wulfen ssp. Tergestinus, *Minuartia circaussica* (Albov) Woronow, *Sagina subulata* (Sw.) C.Presl., *Helianthemum appeninum* (L.) Mill, *Sedum subulatum* (C.A.Meyer) Boissier, *Sedum telephium* ''Matrona'', *Geranium maculatum* «Elizabeth Ann», *Geranium phaeum* L., *Geranium pratense* L., *Ajuga orientalis* L., *Hylotelephium sieboldii* (Sweet ex Hook.), *Sedum acre* L., *Sedum aizoon* L., *Sedum album* L., *Sedum erythrostictum* ''Mediovariegata'', *Sedum ewersii, Sedum hispanicum* L., *Sedum rupestre* L., *Sedum. sediforme* (Jacg.) Pau., *Sedum sexangulare* L., *Sedum spectabile* "Brilliant", *Sedum spectabile* "Variegata", *Nepeta mussinii* Henke., *Nepeta transcaucasica* Grossh., *Prunella grandiflora* (L.) Scholl., *Stachys macrantha* (K. Koch) Stearn, *Thymus serpyllum* L., *Perovskia atriplicifolia* Benth., *Oenothera missouriensis* Sims., *Anemone sylvestris* L., *Potentlla alba* L. |
| Euxerophyte | *Anthemis sosnovskyana* Fed.,*Alyssum repens* Baumg, *Sedum spectabile* Star Dust., *Sempervivum tectorum* L., *Opuntia humifusa* Raf. *Eriophyllum lanatum* (Pursh) Forbes., *Draba brumifolia* Steven, *Cerastium biebersteinii* DC., *Sedum hybridum* L., *Sempervivum hybridum* "Faraon", *Sempervivum ruthenicum* (W. D. J. Koch) Schnittsp. et C. B. Lehm., *Euphorbia cyparissias* L., *Veronica armena* Boiss.et Huet. |
| Eumezophyte | *Solidago hybride* «Laurin»,*Solidago Hybride* "Nana",*Solidago Hybride* ,Cloth of Gold,*Solidago hybrid* Strahlenkrone, *Dicentra spectabilis* (L.) Lem. Alba, *Geum x hybridum hort* |
| Hydromezophyte | Mentha piperita L., Limonium scoparium (Pall. ex Willd.) Stank., Lysimachia nummularia L. |
| Gigrophyte | *Duchesnea indica* (Andr.) Focke |

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