



Ecological and biological features of *phacelia tanacetifolia* benth. in various ecotopes of Southern European Russia

Vladimir I. Cherniavskikh ^{1*}, Elena V. Dumacheva ¹, Valery V. Konoplev ¹, Julia E. Shchedrina ², Tatyana N. Glubsheva ¹, Svetlana V. Korolkova ¹, Daniil P. Koryakov ²

¹ Belgorod State University, 85, Pobedy St., Belgorod, 308015, RUSSIA

² Department of agro-industrial, complex and Environmental Reproduction of the Belgorod Region, 24, Popova St., Belgorod, 309292, RUSSIA

*Corresponding author: cherniavskikh@mail.ru

Abstract

The article contains the results of the study of the environmental and biological features of *Ph. tanacetifolia* in four natural and territorial complexes of the Belgorod region. In all natural-territorial complexes *Ph. tanacetifolia* accompanied by dominant species such as: *M. albus* Medik., *Ch. album* L., *E. canadensis* L., *E. repens* (L.) Nevski, *S. pumila* (Poir.) Roem. & Schult., *C. xanthiifolia* (Nutt.) Fresen., *L. amplexicaule* L., *M. lupulina* L. The broad amplitude of variation is established by such morpho-biological indices of wild-growing individuals *Ph. tanacetifolia* as plant height (Cv = 34.8-46.7%), bush diameter (Cv = 43.2-54.5%), scape diameter (Cv = 67.1-78.4%), inflorescence length (Cv = 46.7-55.2%); 1000 seed's weight (Cv = 25.4-37.4%); number of curls per plant (Cv = 49.2-63.5%); number of flowers in the curl (Cv = 33.4-42.7%); number of seeds in the inflorescence (Cv = 25.4-28.6%); seed productivity (Cv = 30.6-34.8%). The allocated wild-growing forms of a phacelia are included in collection nursery of a botanical garden of NRU «BelSU».

Keywords: natural-territorial complexes, wild populations, morphological signs, variation of signs, melliferous culture

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INTRODUCTION

Among the main melliferous plants (linden tree, raspberry, fruit trees, berry shrubs and herbs), as well as crops cultivated in crop rotations (buckwheat, clover and Lucerne, leguminous etc.), in recent years the most important role is given to the phacelia (Cherniavskikh et al., 2018; Butcaru et al., 2019; Büchi et al., 2020; Petanidou, 2003; Sorbi, & Farrokhnia, 2018).

Phacelia tanacetifolia is an excellent nectariferous and melliferous culture and can be used in both monoculture and cover. There is a perspective of an application of decorative properties of phacelia in green construction and decorative flower growing (Sikora et al., 2016; Titov & Mamonov, 2013; Barbir et al., 2015).

Special importance is attached to the study of melliferous plant resources, peculiarities of their biology, pollination and fertilization, growth and development (Dumacheva et al., 2017; Dumacheva et al., 2018; Chernyavskikh et al., 2019).

Phytosanitary monitoring is carried out and the number and species of pollinators *Ph. tanacetifolia* are actively studied. Plant interactions in agrophytocenosis are actively investigated (Stanek et al., 2019; Westphal et al., 2006; Totland et al., 2006).

The purpose of the work is to study phytocenoses with the participation of *Ph. tanacetifolia* in various natural and territorial complexes of the Belgorod region and morpho-biological features of this valuable species were evaluated.

MATERIAL AND METHODS

In route studies, in 2017-2018 the spread of wilt forms of type *Ph. tanacetifolia* in the natural communities were studied. To find and evaluate them, geobotanical descriptions and selections of wild forms were carried out in meadows, hayfields, pastures, roadside areas according to conventional methods (Field geobotany, 1972; Dospekhov, 2012). The methodological basis of the research was the concept of formation in the south of the Center Russian upland of the secondary anthropogenic microgenecentre of the formation of individual synanthropic plant species (Cherniavskikh et al., 2018; Dumacheva et al., 2017; Dumacheva et al., 2018; Chernyavskikh et al., 2019).

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Fig. 1. Habitats *Ph. tanacetifolia* concentrated near the settlements (photo V. Cherniavskih)

The researches were carried out in six districts of the Belgorod region, belonging to four different sub-sites of regional natural and territorial habitat (NTH):

1. Krasnoyarskiy district – Vorsklinskiy NTH (precipitation from 575 to 640 mm/year; grey forest soils and black earths podsolized).

2. Belgorodskiy, Volokonovskiy, Chernyanskiy districts – Oskolo-Severskodonetskiy NTH (area of 1.5 km²; precipitation – 525-585 mm; soils: grey forest, black earth typical, leached and podzolized).

3. Krasnogvardeyskiy district – Potudansko-Tihosovenskiy NTH (density of gully-beam network– 1.5-2 km/km²; precipitation – 525-585 mm; forest-field wavy loam plains with black earth typical and leached) prevail.

4. Alekseyevskiy district – Kalitvinsko-Urayevskiy NTH (precipitation is 470-500 mm/year; soil cover erodibility – 57-64%; soils are represented by common blackearths, as well as washed carbonate blackearths and turf soils on Cretaceous rocks with calcesite vegetation) (Lisetskiy et al., 2005).

The structure of the communities was determined according to the requirements of geobotanic studies at the sample areas. The results were statistically processed (Field geobotany, 1972).

RESULTS AND DISCUSSION

Information about mechanisms of adaptation in *Ph. tanacetifolia* cenopopulation were obtained both direct

experiments based on the study of spatially separate cenopopulations and comparative studies of isolated coenopopulations in multiple ecosystems.

Ph. tanacetifolia habitats have been established on the territory of a number of districts of the Belgorod region: Belgorodskiy, Krasnoyarskiy, Alekseyevskiy, Krasnogvardeyskiy, Volokonovskiy, Chernyanskiy. All habitats are concentrated near settlements, former farms or pastries, garbage dumps, roadsides (**Fig. 1**).

By its confoundedness with a certain water regime *Ph. tanacetifolia* is mesophyte. A cenotic group is a cultured and outgoing species. By the time of the import, depending on the region – cenophyte or eucenophyte. By the method of migration – ergasiophyte. By degree of naturalization – ephemerophyte-epycophyte or ergasiophygophyte.

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The total projective coating at the test sites was in the range between 15-25%. Conducted study of the prevalence of dominant species in *Ph. tanacetifolia* habitats showed that in all natural-territorial complexes *Ph. tanacetifolia* dominant species such as: *M. albus* Medik., *Ch. album* L., *E. canadensis* L., *E. repens* (L.) Nevski, *S. pumila* (Poir.) Roem. & Schult., *C. xanthiifolia* (Nutt.) Fresen., *L. amplexicaule* L., *M. lupulina* L.

Individuals of *Ph. tanacetifolia* from Krasnoyarskiy, Krasnogvardeyskiy and Alekseyevskiy districts had a light green color of leaves, in Belgorodskiy and Volokonovskiy districts had an average intensity of green color, in Chernyanskiy district a dark green color.

In Krasnoyarskiy, Belgorodskiy, Chernyanskiy and Alekseyevskiy districts the time of the beginning of flowering is earlier, in Volokonovskiy and Krasnogvardeyskiy districts – the average. Individuals of *Ph. tanacetifolia* with late flowering was not detected.

Plant height in *Ph. tanacetifolia* individuals varies from low – 50-70cm in Volokonovskiy district to high – 92-114cm – in individuals of phacelia in Krasnoyarskiy district.

The *Ph. tanacetifolia* leaf length in us researches changed from 6.8-8.8 cm in individuals of phacelia in the Belgorodskiy district to 8.7-10.7 cm in the Alekseyevskiy district. Increasing in length of leaves happened consistently among the Belgorodskiy district → Volokonovskiy → Krasnoyarskiy → Chernyanskiy → Krasnogvardeyskiy → Alekseyevskiy (**Fig. 2**).

The width of leaves of *Ph. tanacetifolia* varied from 3.8-6.4 cm in Krasnoyarskiy district to 5.0-7.1 cm in Krasnogvardeyskiy district. Increase in width of leaves happened consistently among Krasnoyarskiy district



Fig. 2. Resizing *Ph. tanacetifolia* in various habitats (photo of V. Cherniavskih)

→ Alekseyevskij → Volokonovskij → Belgorodskij → Chernyanskiy → Krasnogvardeyskij.

The anthocyanic colour of the leaves is absent or weak in *Ph. tanacetifolia* individuals from Krasnoyarskiy and Belgorodskij districts. The average intensity of anthocyan colour is noted in individuals of phacelia from Chernyanskiy and Alekseyevskij districts. The strong intensity of anthocyan colour is expressed in individuals of *Ph. tanacetifolia* from Volokonovskij and Krasnogvardeyskij districts.

Color of colors at *Ph. tanacetifolia* is one of the most important and weakly changing features. Blue-purple is found to be typical of *Ph. tanacetifolia* from Belgorodskij, Volokonovskij and Chernyanskiy districts. Red-purple color is marked in individuals of coenopopulations from Alekseyevskij and Krasnogvardeyskij districts. In individuals from Krasnoyarskiy district the colour of the corolla is of blue shade.

An important characteristic of *Ph. tanacetifolia* is the degree of leaf downiness. A weak downiness has been detected in *Ph. tanacetifolia* individuals from Krasnoyarskiy, Alekseyevskij and Krasnogvardeyskij districts. The *Ph. tanacetifolia* from Volokonovskij and Chernyanskiy districts has an average degree of leaf downiness. The *Ph. tanacetifolia* from the Belgorodskij district has a strong degree of leaf downiness.

Stem branching in the wild-growing *Ph. tanacetifolia* individuals in various areas raised among: Volokonovskij = Alekseyevskij = Krasnogvardeyskij → Chernyanskiy → Krasnoyarskiy = Belgorodskij district.

The length of inflorescences of *Ph. tanacetifolia* was measured during the full flowering period, when the curls were fully spun. The length of the curls in the wild-growing *Ph. tanacetifolia* individuals in various areas changed among: Volokonovskij (5.2-8.9 cm) → Belgorodskij (6.7-11.4 cm) → Chernyanskiy (7.2-11.6 cm) → Krasnoyarskiy (9.6-15.0 cm) → Krasnogvardeyskij (11.5-16.4 cm) → Alekseyevskij (12.1-17.7 cm) districts.

By the number of curls of *Ph. tanacetifolia* in the coenopopulations of the various districts of the Belgorodskij region it is possible to distribute in a row on increase: Krasnogvardeyskij → Belgorodskij → Alekseyevskij → Volokonovskij → Chernyanskiy → Krasnoyarskiy.

By weight of 1000 seeds of *Ph. tanacetifolia* in the coenopopulations of various districts of the Belgorodskij region it is possible to distribute in a row on increase of size of an indicator: Krasnoyarskiy → Chernyanskiy → Belgorodskij → Volokonovskij → Krasnogvardeyskij → Alekseyevskij district.

The light brown color has *Ph. tanacetifolia* plant seeds, growing in Krasnoyarskiy and Krasnogvardeyskij districts. The average intensity of a brown colour has a phacelia from Volokonovskij, Chernyanskiy and Alekseyevskij districts. Phacelia from the Belgorodskij district had a dark brown seed color.

Phytocenoses of Alekseyevskij, Chernyanskiy and Krasnogvardeyskij districts were dominated by individuals with a sprawling form of bush with the diameter from 45 to 56 cm. In Krasnoyarskiy, Belgorodskij and Volokonovskij districts there were dominated by individuals with a semi-closed form of bush with diameter from 33 to 47 cm.

The productivity of the above-ground phytomass and *Ph. tanacetifolia* seeds were studied depending on the place of growth under conditions of the natural cenopopulation in different districts of the Belgorodskij region (**Table 1**).

The indicator of the number of inflorescences (curtains) on one plant of the *Ph. tanacetifolia* changed from minimum (6.5±1.16) to maximum (10.4±1.30) in a row on districts: Krasnogvardeyskij → Belgorodskij → Alekseyevskij → Volokonovskij → Chernyanskiy → Krasnoyarskiy.

The number of flowers in the curtains of the *Ph. tanacetifolia* changed from minimum (100.0±3.8) to

Table 1. Productivity of the above-ground phytomass and *Ph. tanacetifolia* seeds in a natural phytocenoses of the Belgorodskij region (2017-2018)

Indices	Districts of the Belgorodskij region					
	Krasnoyarskiy	Belgorodskij	Volokonovskij	Chernyanskiy	Alekseyevskij	Krasnogvardeyskij
Number of curls on the plant, pcs.	10.4±1.30	7.6±1.11	8.9±1.09	9.1±1.14	8.6±1.11	6.5±1.16
Number of flowers in the curl, pcs.	138±4.6	120±3.7	132±5.0	128±3.3	110±4.8	100±3.8
Number of seeds in inflorescences, pcs.	38.9±1.11	29.4±1.09	32.4±1.11	30.3±1.22	28.2±1.36	26.1±1.44
Seed efficiency, g/1 plant	1.66±0.09	0.95±0.03	1.22±0.04	1.12±0.07	0.85±0.02	0.78±0.05
Leaf coverage, %	46±1.4	39±1.7	40±1.9	44±2.6	38±2.2	42±3.1
Drought hardness, grades	4.6±0.9	4.0±0.7	4.0±0.7	3.4±0.9	3.8±0.4	4.2±0.7

maximum (138±4.6) in a row on districts: Krasnogvardeyskij → Alekseyevskij → Belgorodskij → Chernyanskij → Volokonovskij → Krasnoyarskij.

The number of seeds in the inflorescences of the *Ph. tanacetifolia* changed from minimum (26.1±1.44) to maximum (38.9±1.11) in a row on districts similarly to quantity of inflorescences on phacelia plants: Krasnogvardeyskij → Alekseyevskij → Belgorodskij → Chernyanskij → Volokonovskij → Krasnoyarskij.

The seed productivity of *Ph. tanacetifolia* was evaluated. The magnitude varied from minimum (0.78 ± 0.05) to maximum (1.66 ± 0.09) in a row on districts similar to the number of inflorescences on *Ph. tanacetifolia* plants and to quantity of seeds: Krasnogvardeyskij → Alekseyevskij → Belgorodskij → Chernyanskij → Volokonovskij → Krasnoyarskij.

The leaf coverage of the *Ph. tanacetifolia* was evaluated. Its size changed from minimum (38.0±2.2%) to maximum (46.0±1.4%) in a row on districts: Alekseyevskij → Belgorodskij → Volokonovskij → Krasnogvardeyskij → Chernyanskij → Krasnoyarskij.

There was made an evaluation of the coefficient variation of the main characteristics of the *Ph. tanacetifolia* within the limits studied by the cenopopulations and between populations growing in different PTC and in different districts of the Belgorodskij region.

The broad amplitude of variation is established for a number of morpho-biological indices of wild-growing *Ph. tanacetifolia* individuals in the four PTC of the Belgorodskij region, such as plant height (Cv = 34.8-46.7%), bush diameter (Cv = 43.2-54.5%), stem

diameter (Cv = 67.1-78.4%), inflorescence length (Cv = 46.7-55.2%); 1000 seed weight (Cv = 25.4-37.4%); number of curls per plant (Cv = 49.2-63.5%); number of flowers in the curl (Cv = 33.4-42.7%); number of seeds in inflorescence (Cv = 25.4-28.6%); seed productivity (Cv = 30.6-34.8%).

CONCLUSION

1. It is for the first time in the conditions of six districts of the Belgorodskij region the study of a wild cenopopulation of *Ph. tanacetifolia* has been conducted. Six identified *Ph. tanacetifolia* habitats are concentrated near settlements, former farms or bee-farms, garbage dumps, roadsides.

2. There are separated wild-growing forms with valuable properties (long period of flowering, early onset of flowering phase, drought resistance, seed productivity).

3. Samples separated during the study of wild forms of phacelia are included in the nursery collection of the botanical garden of NRU «BelSU».

4. Due to the complex of signs of the ecological stability and adaptability, the isolated samples of *Ph. tanacetifolia* can be used as a source material to create a feed base for beekeeping in various regions of Russia.

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