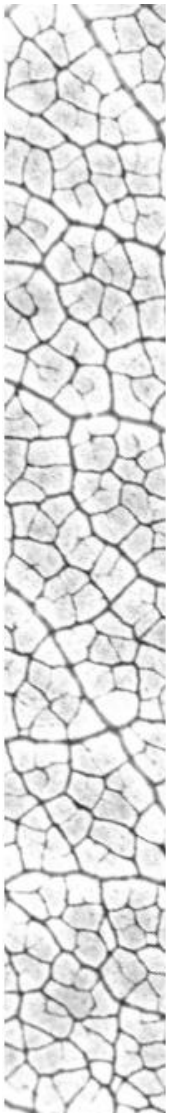

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Ecological and biological features of *phacelia tanacetifolia* benth. in various ecotopes of Southern European Russia

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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 (Cherniavskih 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 (Cherniavskih 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.Krasnoyaruzhskij district – Vorsklinskij NTH (precipitation from 575 to 640 mm/year; grey forest soils and black earths podsolized).

2. Belgorodskij, Volokonovskij, Chernyanskij districts – Oskolo-Severskodonetskij NTH (area of 1.5 km/km^2; precipitation – 525-585 mm; soils: grey forest, black earth typical, leached and podzolized).

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

4. Alekseyevskij district – Kalitvinsko-Urayevskij 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: Belgorodskij, Krasnoyaruzhskij, Alekseyevskij, Krasnogvardeyskij, Volokonovskij, Chernyanskij. 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 –cenophite or eucenophyte. By the method of migration – ergasiophyte. By degree of naturalization – ephemerophyte-epecophyte 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 Krasnoyaruzhskij, Krasnogvardeyskij and Alekseyevskij districts had a light green color of leaves, in Belgorodskij and Volokonovskij districts had an average intensity of green color, in Chernyanskij district a dark green color.

In Krasnoyaruzhskij, Belgorodskij, Chernyanskij and Alekseyevskij districts the time of the beginning of flowering is earlier, in Volokonovskij and Krasnogvardeyskij 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 Volokonovskij district to high – 92-114cm – in individuals of phacelia in Krasnoyaruzhskij district.

The *Ph. tanacetifolia* leaf length in us researches changed from 6.8-8.8 cm in individuals of phacelia in the Belgorodskij district to 8.7-10.7 cm in the Alekseyevskij district. Increasing in length of leaves happened consistently among the Belgorodskij district → Volokonovskij → Krasnoyaruzhskij → Chernyanskij → Krasnogvardeyskij → Alekseyevskij (**Fig. 2**).

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

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

→ Alekseyevskij → Volokonovskij → Belgorodskij → Chernyanskij → Krasnogvardeyskij.

The anthocyanic colour of the leaves is absent or weak in *Ph tanacetifolia* individuals from Krasnoyaruzhskij and Belgorodskij districts. The average intensity of anthocyan colour is noted in individuals of phacelia from Chernyanskijand 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 Chernyanskij districts. Red-purple color is marked in individuals of coenopopulations from Alekseyevskij and Krasnogvardeyskij districts. In individuals from Krasnoyaruzhskij 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 Krasnoyaruzhskij, Alekseyevskij and Krasnogvardeyskij districts. The *Ph. tanacetifolia* from Volokonovskij and Chernyanskij 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 → Chernyanskij → Krasnoyaruzhskij = 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) → Chernyanskij (7.2-11.6 cm) → Krasnoyaruzhskij (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 → Chernyanskij → Krasnoyaruzhskij.

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: Krasnoyaruzhskij → Chernyanskij → BelgorodskijVolokonovskij → Krasnogvardeyskij → Alexeyevskij district.

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

Phytocenoses of Alekseyevskij, Chernyanskij and Krasnogvardeyskij districts were dominated by individuals with a sprawling form of bush with the diameter from 45 to 56 cm. In Krasnoyaruzhskij, 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 → Chernyanskij → Krasnoyaruzhskij.

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					
	Krasnyaruzhskij	Belgorodskij	Volokonovskij	Chernyanskij	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
Droughthardness, 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 rowon districts: Krasnogvardeyskij → Alekseyevskij→ Belgorodskij → Chernyanskij→ Volokonovskij → Krasnoyaruzhskij.

The number of seeds in the inflorescencesof 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 → Krasnoyaruzhskij.

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 → Krasnoyaruzhskij.

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 → Krasnoyaruzhskij.

There was made an evaluation of the coefficient variation of the main characteristics of the *Ph. tanacetifolia* within the limits studied by the cenopopultions 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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REFERENCES

Barbir J, Badenes-Pérez FR, Fernández-Quintanilla C, Dorado J (2015) The attractiveness of flowering herbaceous plants to bees (*Hymenoptera*: Apoidea) and hoverflies (*Diptera*: Syrphidae) in agro-ecosystems of Central Spain. Agricultural and forest entomology,17 (1): 20–28. https://doi.org/10.1111/afe.12076

Büchi L, Wendling M, Amossé C, Jeangros B, Charles R (2020) Cover crops to secure weed control strategies in a maize crop with reduced tillage. Field crops research, 247: 107583. https://doi.org/10.1016/j.fcr.2019.107583

Butcaru AC, Stanica F, Matei GM, Matei S (2019) Influences of soil ameliorative plant species on organic edible rose culture. Acta horticulturae, 1242: 107–114. https://doi.org/10.17660/ActaHortic.2019.1242.15

Cherniavskih VI, Dumacheva EV, Gorbacheva AA, Vorobyova OV, Ermakova LR (2018) The Use of Morphobiological Characteristics in the Selection of *Phacelia tanacetifolia* Benth. International Journal of Green Pharmacy, 12 (2): 433–436.

Chernyavskikh VI, Dumacheva EV, Sidelnikov NI, Lisetsky FN, Gagieva LCh (2019) Use of *Hissopus officinalis* L. culture for phyto-melioration of carbonate outcrops of anthropogenic origin the South of European Russia. Indian Journal of Ecology, 46 (2): 221–226.

Dospekhov BA (2012) Field experience methodology (with basic statistical processing of research results). M.: Print on Demand: 352.

Dumacheva EV, Cherniavskih VI, Gorbacheva AA, Vorobyova OV, et al. (2018) Biological resources of the *Fabaceae* family in the Cretaceous south of Russia as a source of starting material for drought-resistance selection. International Journal of Green Pharmacy, Apr.-Jun., (Suppl). 12 (2): 354–358. https://doi.org/10.22377/ijgp.v12i02.178

Dumacheva EV, Cherniavskih VI, Tokhtar VK, Tokhtar LA, et al. (2017) Biological Resources of the *Hyssopus* L. on the South Of European Russia and Prospects of its Introduction. International Journal of Green Pharmacy, 11 (3): 476–480.

Field geobotany (1972) Methodical management. 4. Section: Botany-Geobotanic/ Ed. E.M. Lavrenko, A.A. Korchagina. Moscow: Russian Academy of Sciences of the USSR: 336.

Lisetskiy FN, Peresadko VA, Lukin SV, Petin AN (Ed) (2005) Atlas «Natural Resources and Ecological State of the Belgorod region. Belgorod, Belgorod Regional Printing House. 180.

Petanidou T (2003) Introducing plants for bee-keeping at any cost? – Assessment of *Phacelia tanacetifolia* as nectar source plant under xeric Mediterranean conditions. Plant systematics and evolution, 238 (1–4): 155–168. https://doi.org/10.1007/s00606-002-0278-x

Sikora A, Michołap P, Kelm M (2016) Flowering Plants Preferred by Bumblebees (*Bombus* Latr.) in the Botanical Garden of Medicinal Plants in Wrocław. Journal of apicultural science, 60 (2): 59–68. https://doi.org/10.1515/jas-2016-0017

Sorbi A, Farrokhnia A (2018) Landslide Hazard Evaluation and Zonation of Karaj-Chalus Road (North of Iran). International Journal of Geography and Geology, 7(2): 35-44.

Stanek N, Teper D, Kafarski P, Jasicka-Misiak I (2019) Authentication of phacelia honeys (*Phacelia tanacetifolia*) based on a combination of HPLC and HPTLC analyses as well as spectrophotometric measurements. Lebensmittel-Wissenschaft + [i.e. und] Technologie, 107: 199–207. https://doi.org/10.1016/j.lwt.2019.03.009

Titov VN, Mamonov AN (2013) Role of sweetclover and phacelia in agriculture ecology improvement for droughty left-bank areas of Saratov region. Russian agricultural sciences, 39 (4): 338–341. https://doi.org/10.3103/S1068367413040228

Totland Q, Nielsen A, Bjerknes A-L, Ohlson M (2006) Effects of an exotic plant and habitat disturbance on pollinator visitation and reproduction in a boreal forest herb. American journal of botany, 93 (6): 868–873. https://doi.org/10.3732/ajb.93.6.868

Westphal C, Steffan-Dewenter I, Tscharntke T (2006) Foraging trip duration of bumblebees in relation to landscape-wide resource availability. Ecological entomology, 31 (4): 389-394. https://doi.org/10.1111/j.1365-2311.2006.00801.x