MORPHOLOGY AND STRUCTURE OF RED CLOVER (TRIFOLIUM PRATENSE L.) AND WHITE CLOVER (TRIFOLIUM REPENS L.) COENOPOPULATIONS IN THE REPUBLIK OF TATARSTAN

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Abstract: The article provides an analysis of the morphology, density and vitality structure of the coenopopulations of Trifolium pratense L. and Trifolium repens L., growing in different landscape subzones on the territory of the Republic of Tatarstan. The density of coenopopulations of red clover was 3.0-17.2 pcs / m², the low densities were different for cenopopulations in the subtaiga landscape subzone and in the south of the broad-leaved subzone. The density of shoots in the coenopopulations of white clover was 15.0-48.4 pcs / m², high density distinguished cenopopulations in the south of the broad-leaved subzone, low in the north of the broad-leaved subzone. Generative individuals (shoots) prevailed in the ontogenetic structure of coenopopulations of clover species. For red clover, a negative correlation between population density and the share of generative individuals in the structure of coenopopulations was revealed.

Keywords: red clover, white clover, Trifolium pratense, Trifolium repens, coenopopulation density; vitality structure of coenopopulation

1 Introduction

Red clover (Trifolium pratense L.) is widespread in meadow communities, as well as in the weedy places of the summer-winter-green rod grassy perennial growing in Europe, North Africa, West and Central Asia (Bakin, et al., 2000; Hagen & Hamrick, 1998). White clover (Trifolium repens L.) is a summer-winter-green or summer-green herbaceous perennial polycarpic plant with elongated creeping sympodially growing shoots, which is characterized by Euro-Asian distribution and is found in moist meadows, edges, coastal waters and near roads (Bakin et al., 2000). Both species are widely used in human economic activity, as excellent fodder, melliferous, soil-improving plants (Shpakov et al., 2002; Sagirova & Panina, 2016; Kirk & Howes, 2012). Red clover is one of the main legumes in the European part of the globe (Dabkeviciene, et al., 2016).

In addition, both types of clover are widely used in folk medicine for bronchial asthma, shortness of breath, cough, dysentery, pulmonary tuberculosis, metabolic diseases and urolithiasis, kidney diseases. Essential and fatty oils, tannins, glycosides, organic acids, vitamins accumulate in the green mass of red clover, flavones and flavonols, flavonoids, coumarin, triterpene saponins, phenols and other compounds accumulate in the flowers (Drenin & Botirov, 2017; Sabudak et al., 2008; Kamel et al., 2016; Zaitseva & Pogulyaeva, 2017). In the aerial part of the white clover plant, glycosides, flavonoids and tannins, essential oil, ascorbic acid, carotene, and other substances were found (Drenin & Botirov, 2017; Abramchuk & Karpukhin, 2019). A study of the biochemical productivity of red clover and white clover plants in the Republic of Tatarstan (Mikhailov et al., 2019) showed that the content of biologically active substances in plants depends on the location of clover coenopopulations.

The Republic of Tatarstan covers four landscape subzones: the southern taiga and subtaiga subzones in the boreal landscape zone, as well as broad-leaved and forest-steppe subzones in the subboreal northern seven-humid landscape zone (Ermolaev & Igonin, 2006). In connection with the diversity of landscape subzones in the republic, studies of the morphological characteristics of plants and the structure of natural coenopopulations of economically significant plants are relevant. These data are important for assessing the yield of wild resource plants of a particular region. The present study is devoted to the analysis of the morphology, density, and vitality structure of coenopopulations of Trifolium pratense L. and Trifolium repens L., growing in different landscape subzones in the Republic of Tatarstan.

2 Metods

Research material was collected in the summer of 2018-2019.
We studied 12 cenopopulations of red clover (CRC) in meadow and fringe communities located in all landscape subzones represented in the Republic of Tatarstan: southern taiga (CRC-1), subtaiga (CRC-2, CRC-3), broad-leaved (CRC-4, CRC-5, CRC-6, CRC-7, CRC-8, CRC-9, CRC-10 and CRC-11) and forest-steppe (CRC-12).

Also examined were 11 cenopopulations of Creeping Clover (CWC) in meadow, forest, forest, and roadside communities. They are located in the subtaiga (CWC-1, CWC-2, CWC-3) and broad-leaved landscape subzones (CWC-4, CWC-5, CWC-6, CWC-7, CWC-8, CWC-9, CWC-10 and CWC-11).

When assessing the ontogenetic state of plants, the development of N.P. Krylova and T.A. Rabotnova (Krylov & Rabotnov, 1975). As part of various populations of clover species, 5 plots 1–1 m in size were laid, on which all plants were dug for further morphometric analysis. In white clover, an escape was chosen as the counting unit. The height of the plants (shoot length of white clover), dry shoot and inflorescence biomass, reproductive effort (the ratio between the dry inflorescence and shoot biomass) were determined in the collected plants. Generative individuals were analyzed. The sample size for clover red was 11-43 plants, for white clover - 8-94 shoots. All data were processed statistically (Software package for statistical and biometric-genetic analysis in crop production and selection AGROS, 1999).

The vitality structure of the populations was investigated by the dry shoot biomass index taking into account the methodological recommendations of Yu.A. Zlobin (Yu & Zlobin, 2009). The type of vitality structure of coenopopulations was determined by the value of the Q criterion: 1. $Q = 1/2\ (a + b) > c$ - prosperous; 2. $Q = 1/2\ (a + b) = c$ - equilibrium; 3. $Q = 1/2\ (a + b) < c$ - depressive.

3 Results and Discussion

The density of coenopopulations of red clover varied at different research points from 3.0 to 17.2 pcs / m² (Fig. 1, A). In the subtaiga landscape subzone and in the south of the broad-leaved subzone (CRC-9, CRC-10, CRC-11), the density of clover populations was the lowest. The maximum density of individuals distinguished 2 cenopopulations in the north of the broad-leaved subzone (CRC-4, CRC-5).

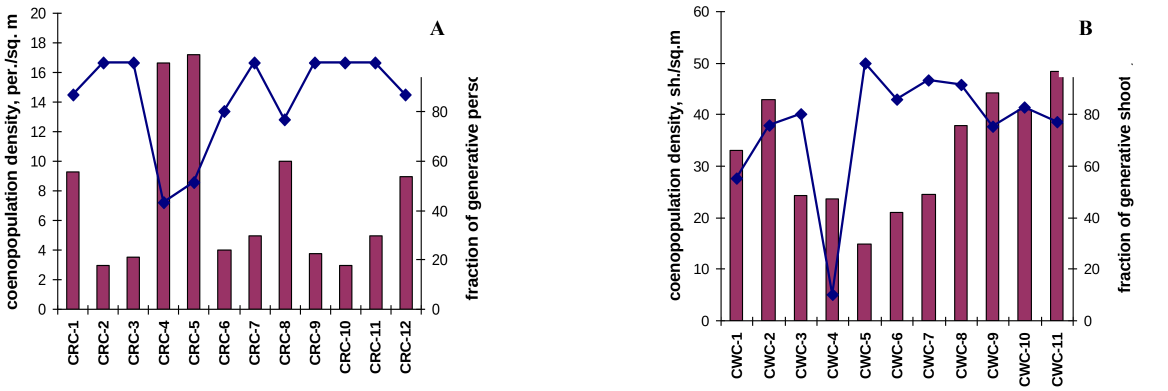

Fig 1: Density of coenopopulations and the fraction of persons (shoots) in the generative state in coenopopulations of red clover (A) and white clover (B).
Note: bars denote the values of the density of coenopopulation.

In white clover, the density of coenopopulations varied from 15.0 to 48.4 shoots per 1 m^2 (Fig. 1, C). The maximum shoot density was noted for cenopopulations in the south of the broad-leaved subzone (CWC-9, CWC-10, CWC-11); the minimum is for cenopopulations in the north of the broad-leaved subzone.

An analysis of the ontogenetic structure of coenopopulations showed that in clover species generative individuals (shoots) usually prevail in coenopopulations. The exceptions are CRC-4, CRC-5, CWC-4 and CWC-1. Among individuals in the pregenerative period, juvenile, immature, and virginal plants (shoots) were noted.

Relative negative correlation (r = -0.93) was revealed between the population density and the share of generative individuals in the structure of cenopopulations of red clover. Those. as the coenopopulations of red clover age, they gradually thin out, similar processes are described for many other plant species (Prokhorenko et al., 2018).

The results of morphostructural analysis showed that the height of red clover plants in the studied cenopopulations varies from 26 to 60 cm (Fig. 2, A). The price populations in the south of the Republic of Tatarstan (south of the broad-leaved subzone, forest-steppe subzone) are characterized by stunting. The tallest were the plants in the cenopopulations of the subtaiga subzone and in the north of the broad-leaved subzone.

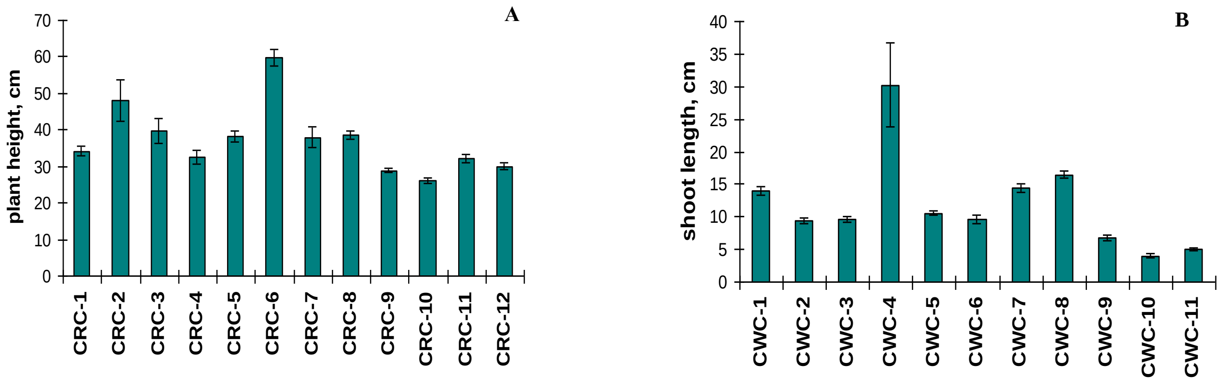

Fig 2: Plant height in coenopopulations of red clover (A) and shoot length in coenopopulations of white clover (B).

The parameter "dry shoot biomass" varies in plants of different coenopopulations of red clover from 2.4 to 8.7 g (Fig. 3, A). Assessment of the reliability of the difference in average values showed that CRC-3 and CRC-7 significantly exceed the other cenopopulations in the considered parameter. High parameter values are characteristic of coenopopulations of the subtaiga subzone and in the center of the broad-leaved subzone.
The reproductive effort of individuals in coenopopulations of red clover ranged from 0.09 in CRC-6 to 0.29 to CRC-9 (Fig. 4, A). These extreme values of the trait significantly differ from the indicators of other coenopopulations. A significant negative correlation was revealed between the reproductive effort of an individual and the height of plants (r = -0.69).

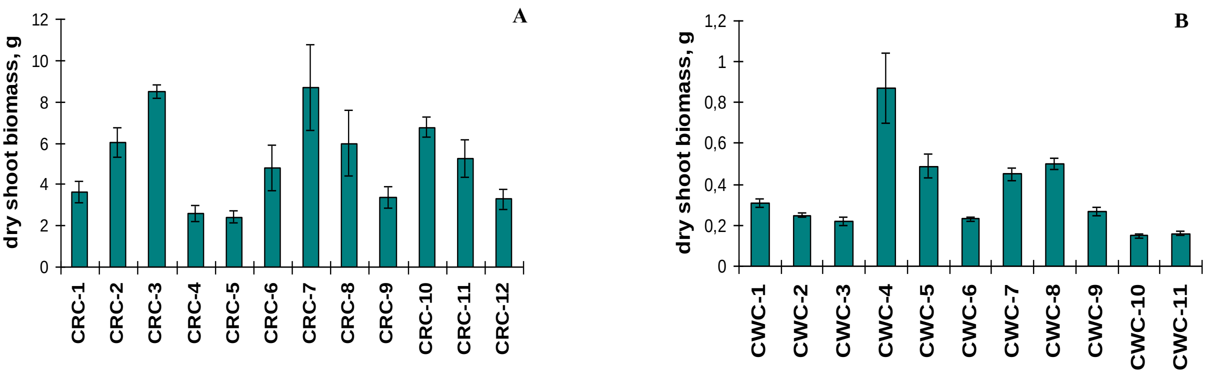

Fig 3: Dry shoot biomass in coenopopulations of red clover (A) and in coenopopulations of white clover (B).

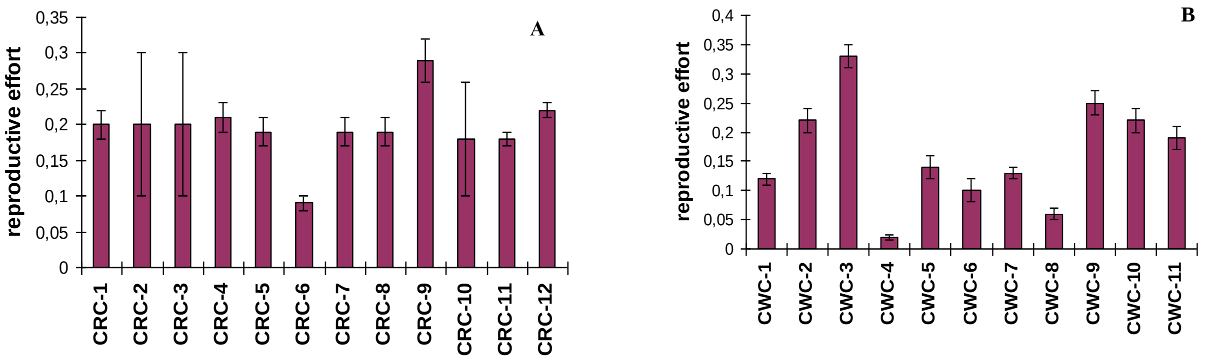

Fig 4: Reproductive effort in coenopopulations of red clover (A) and in coenopopulations of white clover (B).

Also, a significant negative correlation between dry shoot phytomass and cenopopulation density (r = 0.66) was found in red clover.

Cenopopulations of white clover demonstrate a wide range of variability on the basis of shoot length - from 4.0 to 30.3 cm (Fig. 2, B). Among other cenopopulations, significantly exceeding the others in the considered parameter, CWC-4 from the forest community stands out. Low values of shoot length differed in cenopopulation in the south of the broad-leaved subzone.

The parameter “dry shoot biomass” for white clover varies from 0.15 to 0.87 g (Fig. 3, B). The maximum value of the characteristic is characteristic for CWC-4. High values of the indicator characterize cenopopulations of white clover in the north of the broad-leaved subzone, low - cenopopulations in the south of the subzone. In addition, a significant positive correlation was found between the shoot length and its phytomass (r = 0.94).

The reproductive effort parameter for white clover varied from 0.02 for CWC-4 to 0.33 for CWC-3 (Fig. 4, C). The indicator in coenopopulations in the north of the broad-leaved subzone turned out to be significantly lower than in other coenopopulations. Reproductive effort is negatively correlated with shoot length (r = -0.72) and phytomass (r = -0.72).

We ranged individuals by vitality based on the characteristic dry shoot biomass (Tables 1, 2). An analysis of the data showed that among the studied coenopopulations of red clover, the depressive type of the vitality structure prevailed with coenopopulations. At the same time, two coenopopulations with an equilibrium vitality type (in the south of the broad-leaved subzone) and two coenopopulations with a flourishing type of vitality were found (CRC-5 in the north of the broad-leaved subzone and CRC-10 in the south of the broad-leaved subzone). A high proportion of individuals of the highest class of vitality in a population can be interpreted as a sign of its stability and prosperity (Prokhorenko et al., 2018).

We have previously shown that the vital type of coenopopulation of red clover is associated with soil fertility. On poor soils in the north of the subzone of broad-leaved forests, depressive populations form near red clover. Either equilibrium populations or thriving coenopopulations are formed on soils moderately provided with nitrogen and other elements of mineral nutrition (the southern part of the broad-leaved subzone) (Prokhorenko et al., 2020). The presence in the north of a broad-leaved subzone of coenopopulation with a flourishing type of vitality structure is explained by the unevenness of the ecological-coenotic growing conditions.

From the data of table 2 it is seen that all the studied coenopopulations of clover of the white depressive type, characterized by the predominance of individuals with low vitality. For CWC-4, in which vegetative shoots predominated, the calculation of the vitality type of cenopopulation for vegetative shoots was carried out, it also revealed a depressive nature of cenopopulation. We associate the formation of white clover depressive in structure of white clover in the territory of the Republic of Tatarstan with the presence of anthropogenic impact in the form of trampling in the places of growth *T. repens* .

	Q/2 (average share of individuals of higher and middle vitality in coenopopulation)	c (share of individuals of lower vitality in coenopopulation)	Vitality type of coenopopulation
CRC-1	0,265	0,47	depressive
CRC-2	0,295	0,42	depressive
CRC-3	0,285	0,43	depressive
CRC-4	0,203	0,59	depressive
CRC-5	0,398	0,20	thriving
CRC-6	0,275	0,45	depressive
CRC-7	0,250	0,50	depressive
CRC-8	0,320	0,36	depressive
CRC-9	0,333	0,33	equilibrium
CRC-10	0,365	0,27	thriving
CRC-11	0,334	0,33	equilibrium
CRC-12	0,210	0,58	depressive

Table 1: Vitality type of red clover coenopopulations

	Q/2 (average share of shoots of higher and middle vitality in coenopopulation)	c (share of shoots of lower vitality in coenopopulation)	Vitality type of coenopopulation
CWC-1	0,270	0,45	depressive
CWC-2	0,260	0,48	depressive
CWC-3	0,275	0,44	depressive
CWC-4	Not calculated due to small sample size (the number of shoots in the generative state)		
CWC-5	0,285	0,42	depressive
CWC-6	0,220	0,57	depressive
CWC-7	0,260	0,48	depressive
CWC-8	0,295	0,42	depressive
CWC-9	0,255	0,49	depressive
CWC-10	0,260	0,48	depressive
CWC-11	0,275	0,45	depressive

Table 2: Vitality type of white clover coenopopulations

4 Summary

1) The density of coenopopulations of red clover varied from 3.0 to 17.2 pcs / m². The cenopopulations of the subtaiga landscape subzone and the south of the broad-leaved subzone differed in low density. The density of shoots in the coenopopulations of white clover varied from 15.0 to 48.4 pcs / m². High density distinguished cenopopulations in the south of the broad-leaved subzone, low in the north of the broad-leaved subzone. Generative individuals (shoots) prevailed in the ontogenetic structure of coenopopulations of clover species. For red clover, a negative correlation between population density and the share of generative individuals in the structure of coenopopulations was revealed.

2) Morphometric parameters in cenopopulations of red clover were: plant height - 26-60 cm, dry shoot biomass - 2.4-8.7 g, reproductive effort - 0.09-0.29. In coenopopulations of white clover: shoot length - 4.0-30.3, dry shoot biomass - 0.2-0.9 g, reproductive effort - 0.02-0.33.

3) For red clover, significant negative correlations between plant height and reproductive effort of an individual, density of coenopopulation and plant phytomass were revealed. A correlation constellation of signs was found in white clover: shoot length - shoot phytomass - reproductive effort, while the relationship between shoot length and its phytomass was positive, the remaining correlations were negative.

4) The price populations of red clover in the south of the broad-leaved subzone, as well as one of the three studied cenopopulations in the north of the broad-leaved subzone, were distinguished by an equilibrium and prosperous type of vitality structure. The remaining cenopopulations in the north and in the center of the broad-leaved subzone, as well as the cenopopulations of the southern taiga, subtaiga, and forest-steppe subzones, were characterized by a depressive type of vital structure.

Coen populations of white clover in the subtaiga and broad-leaved subzones of the Republic of Tajikistan were characterized by a depressive type of vital structure.

5 Conclusions

It is recommended that the collection of medicinal raw materials be carried out in cenopopulations with high biomass productivity: for red clover, these are cenopopulations of the subtaiga subzone and the central part of the broad-leaved forest zone; for white clover, these are cenopopulations in the north of the broad-leaved forest zone of the Republic of Tatarstan.

Literature:

1. Abramchuk, A.V., & Karpukhin, M.Yu. (2019). The effectiveness of clover (Trifolium L.) in the treatment of various diseases. *Bulletin of Biotechnology,* 3(20), p. 16.
2. Bakin, O.V., Rogova, T.V., & Sitnikov, A.P. (2000). *Vascular Plants of Tatarstan.* Kazan, 496 p.
3. Dabkeviciene, G., Statkeviciute, G., Mikaliuniene, J., Norkoviciene, E., & Kemesyte, V. (2016). Production of Trifolium pratense L. and T. hybridum L. tetraploid populations

and assessment of their agrobiological characteristics. *Zemdirbyste-Agriculture*, 103(4), 377-384.
4. Drenin, A.A., & Botirov, E.Kh. (2017). Flavonoids and isoflavonoids of plants of the genus Trifolium L. structural diversity and biological activity. *Chemistry of Plant Raw Materials*, 3, 39-53.
5. Ermolaev, O.P., & Igonin, M.E. (2006). Landscape Zoning and Mapping of the Middle Volga Region. *Georesurs*, 2(19), 20-23.
6. Hagen, M.J., & Hamrick, J.L. (1998). Genetic variation and population genetic structure in Trifolium pretense. *The Journal of heredity*, 89, 81-178,.
7. Kamel, E.M., Mahmoud, A.M., Ahmed, S.A., & Lamsabhi, A.M. (2016). Phytochemical and computational study on flavonoids isolated from Trifolium resupinatum and their novel hepatoprotective activity. *Food Funct.*, 7, 2094-2106.
8. Kirk, W.D.J., & Howes, F.N. (2012). Plant for Bees, IBRA, 311 p.
9. Krylov, N.P., & Rabotnov, T.A. (1975). Clover meadow. *Biological flora of the Moscow region*, 2, 89-101.
10. Mikhailov, A.L., Timofeeva, O.A., Ogorodnova, U.A., & Stepanov, N.S. (2019). Comparative analysis of biologically active substances in Trifolium pratense and Trifolium repens depending on the growing conditions. *J. Environ. Creative. Tech., Special Issue on Environment, Management and Economy*, 873-876.
11. Prokhorenko, N.B., Kadyrova, L.R., & Demina, G.V. (2020). Ecology and structure of coenopopulations of Trifolium repens L. in the Republic of Tatarstan. *Samara Scientific Bulletin*, 2.
12. Prokhorenko, N.B., Demina, G.V., & Kadyrova, L.R. (2018). Population Structure of Melilotus officinalis (L.) Pall. and Trifolium pratense L. in the zone of deciduous forests of the Republic of Tatarstan. *Samara Scientific Bulletin*, 4, 103-107.
13. Sabudak, T., Dokmeci, D., Ozyigit, F., Isik, E., & Aydogdu, N. (2008). Antiinflammatory and antioxidant activities of Trifolium resupinatum var. microcephalum extracts in arthritic rats. *Asian J. Chem.*, 20, 1491-1496.
14. Sagirova, R.A., & Panina, O.S. (2016). A study of the ontogenetic morphogenesis of creeping clover (Trifolium repens L.) in connection with its introduction in the forest-steppe zone of the Cisbaikalia. *Agronomy*, 2(43), 25-30.
15. Shpakov, A.S., Novoselov, Yu.K., & Kharkov, G.D. (2002). *Clover in field feed production.* Clover of Russia, M, 157-239.
16. Software package for statistical and biometric-genetic analysis in crop production and selection AGROS, (1999). Version-2.08, Tver.
17. Zaitseva, N.V., & Pogulyaeva, I.A. (2017). Ecological and biochemical characteristics of plants of the genus Trifolium L., growing in South Yakutia (for example, Neryunga). *Bulletin of the Samara Scientific Center of the Russian Academy of Sciences*, 19, 2 (3), 441-447.
18. Zlobin, Yu.A. (2009). *Population Ecology of Plants: Current Status, Growth Points.* Sumy: University Book, 263c.

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