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Particular Qualities of Micro Evolutionary Adaptation Processes in Cenopopulations *Medicago* L. On Carbonate Forest-steppe Soils in European Russia

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Abstract: The article is devoted to the study of adaptive micro evolutionary processes in the cenopopulations *Medicago* L. on carbonate forest-steppe soils of the European part of Russia. Identified adaptations and mutations in natural populations of alfalfa allow considering chalky south of the Central Russian Upland as a secondary (anthropogenic) genetic center. It has been found as a result of unprogressive hybridization and adaptive processes. There is a formation of cenopopulations of *M. varia* Martyn of a certain "carbonate" ecotype. The latter is close to cultivated forms in a number of morphological characters and simultaneously has a distinct type of competitive adaptive strategy. Thus, dedicated competitive sustainable multifoliate forms of alfalfa with *mf*-mutation have served as a source material for the creation of the specialized grade Krasnoyarouzhskaya 1.

Key words: Alfalfa (*Medicago* L.) · Cenopopulations · *mf*-mutation · Multifoliate forms · Microevolution · Unprogressive hybridization · Ecotypes · Adaptation · Secondary (anthropogenic) genetic centers of origin of cultivated plants · Forest-steppe · Calcareous soils

INTRODUCTION

Worsening of environmental situation in recent years increased urgency of the search for methods and ways of enhancement of ecological stability and producing capacity of different sorts of plants in adverse environment. Besides changeable moistening conditions, periodic droughts and active erosion processes specifics of steppe and forest-steppe of Central Russian Plain in European part of Russia is increase of calcium carbonate content in soils. Such conditions lead to decrease of general producing capacity of biocenosis as a whole and agrophytocenosis in particular [1-3].

In this situation the species of genus *Medicago* L. attract special attention as the most valuable in economical respect. They also define in most cases the magnitude of biological capacity of erosion agricultural landscapes [4]. But until now scientists argue concerning the search of adaptive indicators and characteristics of alfalfa that provide stability on environmentally adverse carbonated substrates and the possibility of micro evolutionary processes under such a conditions [5-7].

The researches was aimed on learning micro evolutionary adaptation processes in cenopopulation *Medicago varia* Martyn on carbonated soils, defining of stable competitive forms as raw material for development of specialized sorts.

MATERIALS AND METHODS

The research was based on the theory of centers of origin and diversity of cultivated plants [9-11], micro gene centers (anthropogenic gene centers [12-14], centers of discrete origin and areas of diffusive origin of cultivated plants [15-17] as methodological foundation.

Geobotanical research was carried out on the territory of Belgorod region in 2003-2013. Natural assemblages were learned by the process of path research by transect method and by geobotanic descriptions. Observations, record and data processing were made according to standard methodology used in experiments with perennial herbs, field geobotanic research, laboratory experiments [18].

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RESULTS

Several species of alfalfa are dispersed in cretaceous southern territories of Central Russian Upland both as cultivated and wilding plants: *M. sativa* L., *M. falcata* L. subsp. *romanica* (Prodan) Schwarz et Klinkovski (*M. romanica* Prodan, *M. falcata* auct.), *M. varia* Martyn, *M. lupulina* L., *M. borealis* Grossh. They are different in their ecological genetic characteristics.

The greatest interest for learning natural assemblages on carbonated soils is to draw cenopopulation of two species: *M. falcata* è *M. varia*, the most valuable also in economical respect.

It's worth noting that in geobotanic descriptions made in the area of our research by V.I. Taliev 100 years ago [19] *M. varia* wasn't mentioned at all. As our research shows *M. varia* may be found in plant assemblages of steppe, meadow and calcicole erosion landscapes (Table 1).

Frequency of occurrence of specie *M. varia* in vegetable assemblages of ravine-gully complexes tenfold or sometimes even hundredfold lower than that of *M. falcate.* In average the ratio of the frequency of occurrence of these species in vegetable assemblages of ravine-gully complexes is 1:22. We found out that cenopopulations *M. varia* have rather clear coincidence with natural places of inhabitation connected with economical activity of people and grow in ravine-gully complexes near fields that had been used in the system of soil protection and near farm crop rotations.

Table 1: Frequency of *M. falcata* and *M. varia* occurrence in steppe, meadow and calcicole phytocenosis of erosion landscapes, %

Phytocenosis	*M. falcata*	*M. varia*
Meadow steppe	78,0	2,0
True steppe	93,0	3,0
calcicole steppe	82,0	4,0
Vegetable assemblages of cretaceous exposures	51,0	5,0
Meadows	38,0	2,0
In average	68,4	3,2

Apparently all cenopopulations of *M. varia* are the result of occasional bringing. Their forming and further development in contrast relief and microclimate of ravine-beam complexes may be explained by the fact that these ecotopes are analogous to foothills with prevalence of soils with high content of crushed rock where cultivated alfalfa mainly originates from (for example, Central Asia region, North Caucasus, Mediterranean) but with specifics of carbonate content of erosion landscapes of the region. The main morphometric measures of vegetative development of the plants of cenopopulations *M. varia* in steppe meadow and calcicole phytocenosis of erosion landscapes of the southern part of Central Russian Upland are presented in Table 2.

In meadow steppes and true steppes with dense herbage individual *M. varia* were almost similar in main measures. Appearance of individual plants growing in this area is close to wild forms of alfalfa. *M. falcata* has high layering capacity, high thin stems, smaller leafs. Leafiness of individual plants is also close to measures of *M. falcata*. They differ only in coloring of corolla varying from pale blue to dark violet.

Table 2: Morphometric measures of cenopopulations *M. varia* in phytocenosises of erosion landscapes

	Phytocenosis		
Indicator	meadow	steppe	vegetable assemblages of cretaceous exposures
Stem height, sm	64,8±13,2	75,4±11,7	78,5±17,2
Total stem mass, gr	13,6±9,3	18,8±8,2	13,6±4,4
Number of generating organs, pcs	37,6±25,7	38,2±22,4	19,9±7,1
Branchiness, pcs	10,4±1,6	12,8±2,5	10,0±0,9
Leaf area, dm^2/10 stems	1,119±0,642	1,351±0,573	1,063±0,171
Leafiness, %	31,5±4,5	27,3±7,1	42,3±8,8
Number of tendrils, pcs	1,15±0,2	1,18±0,18	2,30±1,31

Table 3: Frequency of occurrence of *M. falcata* and *M. varia* in ravine-gully complexes, %

Ecotope	*M. falcata* L.	*M. varia* Martyn
Slopes of gullies with steppe phytocenosises	95,0	0
Slopes of gullies with calcicole assemblages	98,0	3,0
Mouths of gullies with detrital cones	97,0	8,0
Detrital cones of existing ravines	96,0	7,0
In average	96,5	4,5

In ravine-gully complexes with cretaceous exposures, on pit-run fine and soils with high content of crushed rock level of variety of all main measures of individual *M. varia* was significantly higher.

Branchiness of sprouts of *M. varia* in steppe areas was a bit higher than in meadow. The lowest for analyzed measure variation coefficient equals 11,3% is a characteristic for plants of ravine-gully complexes populations.

Leaf area goes lower in the list: true steppe ? meadow steppe ? ravine-gully complex for 17,2% and 21,3% relatively. Leafiness in ravine-gully complexes in comparison with steppe areas without cretaceous exposures increases for 35,5%, compared with meadow for 25,5%.

Important indicator of hybridization of individual plants in populations is number of tendrils in beans. In meadow and steppe areas number of tendrils in the beans of alfalfa is not more that 1,2 whorls with Cv level about 20%. But in ravine-gully complexes number of tendrils increases on 47,8% (up to 2,3 whorls).

In ravine-gully complexes populations individual plants of *M. varia* are close to cultivated alfalfa in habitus-they have greater leaves, lower branchiness, lower number of generating organs and greater leafiness. In meadows and steppe areas individuals of *M. varia* population are close to wild forms in morphological characteristics.

Apparently in ravine-gully complexes adaptive changes are oriented on preservation of ecotypes with such specific features as greater leafiness, lower number of generating organs with increase of number of beans in collective fruits, number of tendrils in beans and their sowing capacity comparing with populations in meadow and steppe phytocenoses [20].

Further research of cenopopulations *M. varia* in ravine-gully complex ecotopes was aimed on revelation of forms resistant to excess content of carbonates. Selected model areas on slopes have complicated geological content, partitioned relief, active erosion processes and diverse soils and vegetable cover.

According to the research average frequency of occurrence of *M. varia* in ravine-gully complexes is relatively higher that in phytocenosises of erosion landscapes (Table 3). We also found ecotopes without *M. varia* at all – slopes of gullies with steppe phytocenosises. On the slopes of gullies with calcicole assemblages ratio of frequency of occurrence of *M. varia* and *M. falcata* is the lowest and equals 1:33. Most often populations of cenehybrid alfalfa were found in detrital cones of existing ravines (1:14) and in mouths of gullies with detrital cones (1:12).

All age range of plants are present in cenopopulations, populations are normal saturated.

Occurrence of plants of alfalfa with distinctive signs of multifoliate forms that is *mf*-mutation (4-7 leaves on plants) was found in some ravine-gully complexes. The sign of multifoliate forms is recessive and has monohybrid type of inheritance. Mutation occurrence may be considered as natural hybrid (in case of panmixia) of maternal recessive mutation with paternal dominant plants [21]. Information about multifoliate forms of different species of *Medicago* genus described in literature indicates the fact of mutation in extreme growing conditions [6]. N.I. Vavilov [10] was the first to propose the idea of prevalence of dominant genes in the centers of specie areas and recessive (mutant) genes in periphery of these areas. Later P.M. Zhukovski [13] proposed the term "microgene centre". He wrote about primary micro evolutionary processes and "gene nodes" that follow the process of speciation.

According a number of researches species of *Medicago* genus are polymorphous and they are in different stages of microevolution both on subspecies (geographic race) level and ecotype (ecological race) level and individual mutability [6, 22, 23]. Multifoliate forms manifestation together with morphological changes indicates origin cenopopulations *M. varia* from limited number of plants and consanguineous mating in their formation.

CONCLUSION

We have ascertain several possible reasons of excess frequency of occurrence of *M. varia* in lower parts of gullies – in detrital cones of existing ravines and in mouths of gullies with detrital cones. Firstly, it is seeds transfer via slopes of gullies and ravines being ecotone corridors. Secondly, it is the specifics of erosive soil substrate that lead to high coarse gravel content and consequently low distribution of cereals and lower competition. Thirdly it is formation of stable forms under the influence of natural selection in hybrid cenopopulations formed in mouths of gullies from the sorts *M. sativa*, *M. varia* and local forms *M. falcata* cultivated earlier in watershed area.

Under the condition of negative impact of carbonated substrate low resistive forms were rather rapidly eliminated from the population and local cenopopulation of *M. varia* with high preservation capability of individual plants was formed. They have a broad range of adaptive changes that formed the base for micro evolutionary changes in extreme conditions of ecotope.

So, the research leads to the following conclusions.

Observed micro adaptations and mutations on natural cenopopulations of alfalfa allow us to consider cretaceous south of Central Russian Upland as secondary (anthropogenic) genecentre.

Ravine-gully complexes with cretaceous erosions are ecotones with gene plasma, substance and energy transfer down the slope and formation on detrital cones areas of introgressive hybridization and micro evolutionary processes in cenopopulation *M. varia*.

Adaptive processes in local cenopopulation of alfalfa are oriented on preservation of individual plants with morphological, biochemical and other characteristics analogous to those of precinctive calcicole plants. Cenopopulation *M. varia* of a definite “carbonate” type are being formed. It is close to cultivated forms in a number of morphological characteristics and has distinctive type of competitive adaptation strategy.

The research may provide the base for development of ways and methods to increase environmental stability and biological productivity of bean components of biocenosis applying analogous approach. It also allows carrying out effective selection to create high productive competitive and environmentally stable cenopopulation of legumes on carbonated soils.

Forms of multifoliolate forms *M. varia* sampled in natural cenopopulations were used for development of a new sort Krasnoyaruzhskaya 1, submitted in 2012 for State strain test to apply for a patent.

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REFERENCES

1. Jefferies, R.L. and A.J. Willis, 1964. Studies on the calcicole-calcifiige habit and methods of analysis of soil and plant tissues and some results of investigations on four species. Journal of Ecology, 52(l): 121-138.
2. Kotlyarova, E.G., V.I. Cherniavskih and E.V. Dumacheva, 2013. Ecologically Safe Architecture of Agrolandscape is basis for sustainable. Sustainable Agriculture Research, 2(2): 11-24.
3. Lisetskii, F.N. and O.V. Degtyar, 2011. Pastures in the Zone of Temperate Climate: Trends of Development, Dynamics, Ecological Fundamentals of Rational Use. Pastures: Dynamics, Economics and Management. USA, Nova Science Publishers, Inc., pp: 51-85.
4. Dumacheva, E.V. and V.I. Cherniavskih, 2012. Environmental stability and production capacity of economically valuable species Fabaceae in agrophytocenosis with one-specie and mixed herbage on carbonated soils. Scientific Gerald of Belgorod State University. Natural Sciences, 15(134): 51-58.
5. Scheiner, S.M. and H.S. Callahan, 1999. Measuring natural selection on phenotypic plasticity. Evolution (USA), 53(6): 1704-1713.
6. Plennik, R.Ya., 2002. Biomorphical micro evolutional strategies of polymorphic type *Medicago falcata* L. in Siberia. Novosibirsk. Nauka, pp: 94.
7. Sultan, S.E., 2004. Promising directions in plant phenotypic plasticity. Perspectives in Plant Ecology, Evolution and Systematic, pp: 227-233.
8. Dumacheva, E.V. and V.I. Cherniavskih, 2011. Population analysis of species of Medicago genuses in natural vegetable assemblages of Central Russian Upland. The problems of general botanics-traditions and perspectives. Collected papers of Internet-conference of ESAEI of High Professional Education “Kazan (Privolzhski) Federal University”. pp: 82-84.
9. Vavilov, N.I., 1926. Studies on the origin of cultivated plants (in Russian). Bulletin of Applied Botany and Plant Breeding, 14: 1-245.
10. Vavilov, N.I., 1992. Origin and Geography of Cultivated Plants.
11. Goncharov, N.P., 2007. Centers of origin of cultivated plants. VOGIS Gerald, 11(3/4): 561-574.
12. Sinskaya, E.N., 1969. Historical geography of cultivated flora (at dawn of agriculture). Leningrad. Kolos, pp: 480.
13. Zhukovski, P.M., 1971. Cultivated plants and their congener. (Systematics, geography, cytogenetics, ecology, origin, usage). Leningrad. Kolos, pp: 752.
14. Diamond, J., 2002. Evolution, consequences and future of plant and animal domestication. Nature, 418(6898): 700-707.

15. Harlan, J.R., 1971. Agricultural origin canters and noncentre's. Science, 174(4008): 468-474.
16. Harlan, J.R., 1992. Crops and man. Madison, Wisconsin: Amer. Soc. Agronomy, CSSA., pp: 284.
17. Kuptsov, A.I., 1975. Introduction into the geography of cultivated plants. Moscow. Nauka, pp: 296.
18. Lavranko, E.M. and A.A. Korchagina, 1972. Field geobotanics. Study guide. 4. Section: Botanics-Geobotanics. Print house of Academy of Science of USSR., pp: 336.
19. Taliev, V.I., 1904. Vegetation of cretaceous erosive landscapes of Southern Russia. Part I. Proceedings of partnership of testing of nature of Imperial Kharkov University, 39(1): 81-254; and 40(1): 1-282.
20. Degtyar, O.V. and V.I. Chernyavskikh, 2006. The environment-forming role of endemic species in calcicole communities of the southern central Russian upland. Russian Journal of Ecology, 37(2): 143-145.
21. Ibragimova, Kh.I. and V.L. Golodkovski, 1972. On inheritance of polyphylesis of alfalfa. Uzbekistan Biological Magazine, pp: 64.
22. Soskov, Yu. D. and A.A. Kochergina, 2009. Characteristics of hierarchical subsystems in specie system of N.I. Vavilov. Genetic resources of cultivated plants. Problems of evolution and systematic of cultivated plants. International Conference om 120th Anniversary of E.N. Sinskaya. St.-Petersburg. VIR Print House, pp: 22-25.
23. Chandra, A., 2010. Studies on morphological and genetically similarities of Medicago murves and M. doliata to M. Scutellata. Journal of Environmental Biology, 31(5): 803-808.