ORIGINAL ARTICLE

Biological resources of the *Fabaceae* family in the Cretaceous south of Russia as a source of starting material for drought-resistance selection

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Abstract

Aim: The south of the Central Russian Upland is a region with particular natural landscape-climatic conditions, the large anthropogenic load, and the intensive development of agricultural farming. A feature of the area is the high content of calcium carbonate in the soil, which reduces the total biological productivity of biocenoses in general and of agrophytocenoses in particular. **Materials and Methods:** The aim of this work is the study of biological resources of the genera *Medicago* and *Trifolium* species in Cretaceous South of the Central Russian Upland as the most valuable in genetic and economic terms. They, in most cases, determine the amount of biological capacity of erosion agro-landscapes. Objects of the study are wild cenopopulations alfalfa *Medicago varia* Mart. and white clover *Trifolium repens* L. In the midst of reduced interspecific and intraspecific competition on the detrital fans, introgressive hybridization and microevolutionary changes in cenopopulations occur. The founder effect is in evidence; it is the accumulation of recessive genes, forming the reserve for natural selection and processes of intermutations. The adaptation processes in cenopopulations are aimed to the preservation of forms having morphological and biological qualities, similar to the properties of endemic calciphilous vegetation. **Results and Discussion:** The studying of adaptive microevolutionary processes occurring in gullies and gully complexes allowed the authors to develop the concept of formation on the Cretaceous South of the Central Russian Upland the secondary (anthropogenic) microgene center for the formation of commensal species of these genera, as *Medicago, Trifolium*, and others. For the selection of valuable forms under natural conditions, a system of integrated biological indicators is developed: Rhizospheric index and iron index are closely correlated with the parameter of seed productivity and resistance (r = 0.871–0.921) selection by which provides drought-resistance progeny and competitive advantages in mixed crops on calcareous soils. The involvement of genetic resources of wild cenopopulations of alfalfa and clover as starting material is advantageously carried out by methods of recurrent selection. This method obtained a number of new varieties of clover and alfalfa, which have a high drought-resistance, stable seed yield, and wide ecological amplitude. **Conclusion:** Selections with different characteristics of the new varieties of alfalfa and clover are already included in the future schemes of recurrent selection to obtain new, more high-yielding forms.

Key words: Alfalfa, biological resources, drought tolerance, *Fabaceae* genetic resources, *mf*-mutation, morphological characteristics, productivity, recurrent selection, white clover

INTRODUCTION

The south of the Central Russian Upland is a region with particular natural landscape-climatic conditions, the large anthropogenic load, and the intensive development of agricultural farming. A significant place in the territorial structure of agricultural landscapes of the region is occupied by gullies and gully complexes with Cretaceous outcropings that are rich in endemic and epiobiotic species.[1-5]

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Received: 07-06-2018
Revised: 19-06-2018
Accepted: 26-06-2018

A feature of the area is the high content of calcium carbonate in the soil, which leads to a reduction in overall bioproductivity of phytocenoses.[6-8]

Primarily, it affects perennial legumes - essential sources of food and feed protein, pharmaceuticals, and components of agro-landscape systems that play an adaptive role and improve the environment in the different structures of agroecosystems, etc.[9-11]

The aim of the research was to study the biological resources of the genera *Medicago* and *Trifolium* species as the most valuable in genetic and economic terms as starting material for ecological selection for drought resistance.

MATERIALS AND METHODS

Research methodology is based on the doctrine of centers of origin and cultivated plant diversity, microgene centers (anthropogenic gene centers), discrete centers of education, and "diffuse origin" of cultivated plant areas.[12-14] The basis of our research is the concept of secondary anthropogenic microgene center at forming species of the *Fabaceae* family in the Cretaceous South of the Central Russian Upland.[7-9]

Objects of studying are wild cenopopulations alfalfa *Medicago varia* Mart. and white clover *Trifolium repens* L.

Natural communities have been studied in the process of routing research in a variety of natural-territorial complexes in Belgorod region. In the culture, studies were carried out in a selection seed field of Closed JSC "Krasnoyaruzhskayacereal company." The soil of test plot is typical black soil; humus content is of 5.8. The main method of selection work in the culture of alfalfa and clover was periodic selection or recurrent selection.[15,16]

Observations, surveys and statistical data processing were carried out according to standard methods.[7-9]

RESULTS AND DISCUSSION

The greatest diversity of legume grasses synanthropes that are resistant to the carbonate substrate, growing in the wild, is revealed in the orifice of the hollows and on the detrital fans of the gullies. Here is the silt deposit when it rains and during snowmelt, and the demolition of all the genetic material from the surrounding area.

In the midst of reduced interspecific and intraspecific competition on the detrital fans, introgressive hybridization and microevolutionary changes in cenopopulations occur. The founder effect is in evidence; it is the accumulation of recessive genes, forming the reserve for natural selection and processes of intermutations.

The adaptation processes in cenopopulations are aimed at the preservation of forms having morphological and biological qualities, similar to the properties of endemic calciphilous vegetation. The studying of adaptive microevolutionary processes occurring in gullies and gully complexes allowed the authors to develop the concept of formation on the Cretaceous South of the Central Russian Upland the secondary (anthropogenic) microgene center for the formation of commensal species of these genera, as *Medicago*, *Trifolium,* and others.[7-9]

New methodological approaches formed the basis of selection work with perennial grasses. Chosen in the midst of competition and calcareous soils individuals and cenopopulations of perennial herbs of the genera *Medicago* and *Trifolium* are used to obtain cost-effective, with high seed productivity and carrying capacity environmentally sustainable agrocenopopulations as the basis for new drought-resistant varieties. In wild cenopopulations of *M. varia* alfalfa and white clover *T. repens* in selection for drought-resistance individuals with specific morphological characteristics have been selected [Table 1].

Competition and the calcimorphic feature of the soil are the potent ecotope factors of agrocenopopulations differentiation, leading to the survival and preservation of individuals with similar genetic characteristics. In alfalfa, for example, it is evidenced by the appearance in the selection of individuals having the symptom of multifoliolation (*mf*-mutation).[7-9]

The result of longstanding work on attraction of genetic resources of alfalfa and clover wild cenopopulations as starting material for recurrent selection is the new drought-resistant variety populations of these perennial legume grasses.

Scientifically substantiated the system of integrated biological indicators (rhizospheric index and the index of iron), closely correlated with the value of seed productivity and resistance (r = 0.871–0.921), selection of which provides a competitive advantages to progeny in mixed crops on calcareous soils. The result was derived synthetic populations of alfalfa changeable, which became the basis of new varieties Krasnoyaruzhskaya 1 and Krasnoyaruzhskaya 2. New varieties nick in characteristics such as high carrying capacity and stable seed productivity. It makes promising their wide use not only in the Central Black Soil region but also in other regions of Russia. As a result, recurrent selection of the selecting varieties Belgorodskaya 86, Belgorodskaya 7, Krasnoyaruzhskaya 2, as well as individual selectings from local Alfalfa cenopopulations selected in Alekseevsky district of Belgorod region, a new variety population of alfalfa PPL 3/12 is received.

Variety population PPL 3/12 exceeds standard – selecting Belgorodskaya 86 as to the yield of green mass by 21.0 %, hay by 20.8 %, and as to protein content in forage mass

Table 1: Morphological characteristics of wild cenopopulations of *M. varia* and *T. repens* L.

Elements of the morphological description	Description of the individual features	
	M. varia	***T. repens* L.**
Form of autumn or spring after growing rosette	Erect	Creeping
Form of the bush	Erect	Creeping
Number of internodes, pcs.	16-19	9-16
Bushiness	Average	Average
Caules		
Height, cm	110–140	10–12 to 20
Roughness	Low	Medium
Downiness	Weak	Lack
Color of knots	From green to slightly violet	Violet
Branchiness	High	From medium to high
Leaf coverage, %	55–60	46–50
Leaves of middle canopy		
Dimension, cm	Length 2.8–3.6 Width 1.7–2.0	0.9–1.5
Form	Obovate, broadly lanceolate, and lenghthened elliptical	Rounded
Downiness	Very weak, the hairs pressed from the underside of the leaf	Smooth
Coloring	Green	Green
Wax coating	Mild	Mild
Leaves softness degree	Medium soft	Medium soft
Stipules of middle canopy		
Form	Wedge-like	Middle rounded
Downiness	Weak	Lack
Coloring	Green	Pale green
Inflorescence		
Form	Raceme	Capitate
Length (raceme, capitate, spike, or anthela), cm	3.0–5.1	1.5–2.0
Degree of looseness	Coriaceous	Medium
Coloring	Blue, violet of different shades, including mixed	White-pink
Beans: Size, form, coloring, number of curls	Length: 0.5–1.1 cm, width 0.3–0.5 cm, strombuliform with 1.5–4 curls, brown	Small; 0.5–0.8 cm; straight, chestnut-brown coloring
Seeds		
Dimension	Length 1.6–3.0 mm, width 1.0–2.0 mm	Small
Form	Reniform, less often angular oval	Round
Color	Light-brown with a yellowish tint	Yellow predominates, less often brown
% of solid seeds	15–60	8–26
Root system		
Vigor development	Well developed, weakly-branched	Weak
Manifestation of the main root	Well developed	Poorly developed
Presence of nodules	A great number	A great number

M. varia: Medicago varia, T. repens: Trifolium repens

by 15.5 %, while the yield of seeds is above the standard [Table 2].

A new variety of white clover Krasnoyaruzhsky is also obtained by the method of recurrent selection based on selectings from local populations, growing both on Cretaceous outcrops and on intensively pastured pastures in the floodplain of the Korocha and Oskol rivers.

The purpose of selection work with clover was to create a low-grown variety with high decorative qualities for terraces, which at the same time has high seed productivity and technological effectiveness when cultivated for seeds. The general decorativeness of the new variety when cultivated on terraces is better than the variety of Rivendale taken as the standard; the new variety surpasses the seed yield standard by 40% when cultivating seed crops in culture that provides a more guaranteed seed production [Table 3].

The most important biological features of the variety are increased seed productivity of grass stands during cultivation for seeds, the possibility of cultivation on soils with a high content of carbonates (burial of construction debris in urban environments, melioration of technogenically disturbed landscapes, etc.), high resistance to trampling. The variety has wide ecological amplitude and is suitable for creating terrace grass stands in different soil and climatic conditions.

Selections with different characteristics from new varieties of alfalfa and clover are already included in further schemes of recurrent selection to obtain new, even more high-yielding forms.

CONCLUSION

It is established that for the selection of valuable drought-resistant forms of legume grasses in natural conditions; it is necessary to use a system of complex biological indicators: The rhizospheric index and the iron index. Selection on the basis of these characteristics ensures the drought resistance of progeny and its competitive advantages in mixed crops on carbonate soils.

Attracting genetic resources of wildly growing cenopopulations of *M. varia* and *T. repens* as a starting material is expedient to carry out by recurrent selection methods.

New varieties of legumes *M. varia* and *T. repens*, obtained by genetic resources of wild cenopopulations, have high drought resistance, stable seed productivity, and wide ecological amplitude.

Selectings with different characteristics from new varieties of alfalfa and clover are already included in further schemes of recurrent selection to obtain new, even higher yielding varieties.

Table 2: Yield and quality of green mass of alfalfa variety population PPL 3/12 (2012–2014)

Indicators	Belgorodskaya 86	PPL 3/12
Yield of green mass, c/ha	354.5±89.2	428.8±11.6
Yield of hay, c/ha	80.5±2.9	97.2±3.7
Seed productivity, c/ha	2.16±0.31	3.20±0.63
Leaf coverage, %	52.3±0.36	55.6±0.43
Protein, %	20.9±0.14	18.1±0.15
Fiber, %	23.2±0.35	24.5±0.66

Table 3: Productivity and quality of Krasnoyaruzh sky variety (2012–2014)

Indicators	Variety Rivendale	Variety Krasnoyaruzhsky
General decorative effect of terrace grass stand	medium	High
Projective coverage, %	85	100
Seed yield, c/ha	4.7±0.3	2.9±0.4

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Source of Support: Nil. **Conflict of Interest:** None declared.