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WILD POPULATIONS OF *MEDICAGO FALCATA* L. IN SMALL RIVER BASINS OF EUROPEAN RUSSIA AS A SOURCE MATERIAL FOR BREEDING

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Abstract. The genetic resources of wild populations of *Medicago falcata* L. of the Cretaceous South of the Srednerussky Upland in ecotopic conditions of chalky slopes and floodplain meadows in the basins of small rivers Tikhaya Sosna and Manjokha were studied to find the source material for breeding work to create varieties for different cultivation conditions. Evaluation of phytocenotic features, density of cenopopulations, forage and seed species was carried out. The species *M. falcata* forms, both on meadows in floodplains and on chalk slopes, full-membered normal cenopopulations, which have a continual (continuous) distribution of individuals by age groups, stable in time and in space. The centralized ontogenetic spectrum indicates the stable status of *M. falcata* cenopopulations in plant communities in various ecotopes of small river basins. The density of individuals of *M. falcata* was on average 18.9 % higher in cenopopulations of floodplains than in chalk slopes. The density of generative individuals in all studied cenopopulations was on average close and varied within 81.2-83.7 %, which indicates their stability in time and high adaptive potential. The weight of one fruiting model plant of floodplain meadows was 2.28 times higher than on chalky slopes. Seed yield on floodplain meadows was 2.02 times higher than on chalky slopes. Valuable source material for breeding *M. falcata* varieties adapted to different ecotopic conditions was obtained.

Keywords: genetic resources, seed productivity, aboveground productivity, ontogenetic spectrum, age structure of cenopopulations.

1. Introduction

The search and study of genetic resources of perennial alfalfa species is actively conducted all over the world. This is due to the economic importance of the alfalfa crop for mankind. Alfalfa is the basis of roughage for livestock, a valuable crop for the pharmaceutical and food industries, and recently its importance as a biofuel, phytomeliorant, etc. is increasing. [1-4].



As cultivated alfalfa is being actively selected, its genetic diversity is narrowing and, as a consequence, the search for wild forms that have preserved high intra-population polymorphism is expanding.

In many economically developed countries, including the U.S. and EEC countries, there is increasing attention to programs for the use of varieties of local (indigenous) origin for the restoration and conservation of biodiversity of territories [5-8].

For the northern regions of Russia and other countries, the importance of studying the species *Medicago falcata* L. as more resistant to harsh natural and climatic conditions: early autumn and late spring frosts; frost and periodic thaws in winter; reduction of oxygen concentration under the ice crust; conditions of soil and air drought, etc. increases. [9-10].

Another important consideration in the search for valuable forms of *M. falcata* in natural conditions is that highly profitable cash crops such as soybean, sunflower, wheat, etc., often displace alfalfa from the best arable land to the worst areas. Therefore, the search is on for forms that can survive and produce under unfavorable cultivation conditions: on eroded and sloping lands, with low nutrient levels and water availability.

In the Cretaceous south of the Middle Russian uplands, scientists of Belgorod State University are searching for the original forms of valuable crops, including *M. falcata*, within the framework of joint research programs with the leading federal research centers of the Russian Academy of Sciences: Williams Reserch Center for Forage Production and Agroecology and All-Russian Research Institute of Phytopathology [11-15].

The aim of the research was to study the genetic resources of wild populations of *M. falcata* from the Cretaceous south of the Central Russian Upland in the slope and floodplain types of terrain in small river basins to find the source material for breeding work to create varieties for different cultivation conditions.

2. Methods and materials

Studies in 2018-2020 were conducted in the basins of small rivers flowing through the territory of Belgorod region. Researchers from federal research centers of the Russian Academy of Sciences: Williams Reserch Center for Forage Production and Agroecology, All-Russian Research Institute of Phytopathology participated in the studies as part of joint research programs.

The area is cut by a dense network of ravines and gullies. Chalk outcrops are common, resulting in a high carbon content of soils. The duration of the period with average daily air temperature above 0 °C is 225-240 days, and the temperature above 10 °C is 150-158 days [16].

The object of the study is sickle-shaped (yellow) alfalfa (*Medicago falcata* L.), a perennial species whose populations in Belgorod Region grow in a variety of ecotopes: on roadsides, in fallow lands, on steppe plots, on slopes, on edges, along pond banks, in agricultural crops.

A comparative study of yellow alfalfa price populations (CP) was conducted in the basins of two rivers in the Belgorod region [17].

Four cenopopulations were identified for research:

CP 1 – 50.4585940N, 37.7366940E on a slope in the Manjokha River basin (chalk slope);

CP 2 – 50.4608220N, 37.7329200E in a floodplain meadow in the Manjokha River basin (floodplain meadow);

CP 3 – 50.6848990N, 38.5277140E on a slope in the Tikhaya Sosna River basin (chalk slope);

CP 4 – 50.6704330N, 38.4874160E in a floodplain meadow in the Tikhaya Sosna River basin (floodplain meadow).

For the general estimation of cenopopulations and geobotanical environment, 10 standard geobotanical plots of 10x10 m, randomly placed diagonally, were laid in each cenopopulation. For a more accurate assessment of population characteristics, 10 plots were laid in each hundred-meter plot, in which the average population density, density of generative individuals, mass of one fruit-bearing plant were determined, selection of individuals for determination of seed productivity from one plant, compilation of the ontogenetic spectrum of populations were carried out.

A total of 565 plants in cenopopulations in the Manjokha River basin and 589 plants in the Tikhaya Sosna River basin were studied. Single representative plants were cut in the fruiting phase, weighed, and seed production was determined on them by cutting off all copulas. Counting of plants to determine the age structure was carried out on 1 m² counting plots by direct counting.

Statistical processing was performed using formulas for calculation of averages, mean error, and coefficient of variation using the Excel package [18].

3. Results and discussion

As a result of analysis of species composition of vegetation on model plots with growth of cenopopulations with participation of *M. falcata* it has been established that from 20 accompanying species of the higher plants 55 % belong to meadow florocenotype; 20 % to steppe, 20 % to weed plants and 5 % to meadow-steppe species. The studied species are distributed by ecological groups in relation to water as follows: 65 % belong to mesophytes, 25 % to mesoxerophytes, 5 % to mesohygrophytes and 5 % to xerophytes. Life forms are represented by hemicryptophytes - 75 %, therophytes - 20 %, phanerophytes - 5 %.

Their spatial structure, potential productivity, and age spectrum (Table 1) are considered to be the most important complex traits that make it possible to evaluate the hereditary adaptive potential and competitiveness of cenopopulations in interaction with environmental conditions.

Table 1. Spatial structure and productivity of *M. falcata* cenopopulations in floodplains and slopes in small river basins of the Cretaceous South of European Russia

| The river basin | | | M±m | Cv,% | lim |
|-----------------|------|--|-------------|------|-------------|
| Quiet Pine | CP 1 | APD, sp.*(100 m ²) ⁻¹ | 29.3±14.0 | 64.8 | 2.0-61.0 |
| | | GIP, sp.*(100 m ²) ⁻¹ | 25.0±12.0 | 65.4 | 1.7-53.4 |
| | | WFP, γ | 311.4±87.0 | 39.0 | 176.0-592.0 |
| | | SYH, γ | 10.8±6.8 | 80.0 | 1.2-33.3 |
| | CP 2 | APD, sp.*(100 m ²) ⁻¹ | 29.6±12.1 | 50.6 | 8.0-52.0 |
| | | GIP, sp.*(100 m ²) ⁻¹ | 26.2±10.8 | 50.3 | 6.8-44.2 |
| | | WFP, γ | 662.5±110.0 | 22.3 | 479.0-980.0 |
| | | SYH, γ | 24.2±10.4 | 51.2 | 1.2-47.7 |
| Manjoha | CP 3 | APD, sp.*(100 m ²) ⁻¹ | 23.4±10.8 | 54.2 | 9.0-40.0 |
| | | GIP, sp.*(100 m ²) ⁻¹ | 19.1±8.8 | 53.4 | 7.3-32.8 |
| | | WFP, γ | 258.7±79.0 | 38.5 | 147.0-420.0 |
| | | SYH, γ | 9.8±5.1 | 68.0 | 1.0-36.1 |
| | CP 4 | APD, sp.*(100 m ²) ⁻¹ | 33.1±9.5 | 36.3 | 10.0-45.0 |
| | | GIP, sp.*(100 m ²) ⁻¹ | 22.8±6.8 | 39.5 | 6.6-33.6 |
| | | WFP, γ | 638.3±60.1 | 11.0 | 536.0-743.0 |
| | | SYH, γ | 17.3±6.9 | 47.4 | 2.5-37.8 |

Note. APD – average population density, sp.*(100 m²)⁻¹, GIP – density of generative individuals of the population, sp.*(100 m²)⁻¹, WFP – weight of the fruit-bearing plant, SYH – seed yield per plant

The average density of the CP 1 cenopopulation growing on the Cretaceous slopes of the Tikhaya Posna River was 25.2 % higher than that of CP 3 on the Manjokha River slopes, and was 26.4 sp.* $(100 \text{ m}^2)^{-1}$ on average for the two cenopopulations.

The density of generative individuals of CP 1, growing on the chalky slopes of the Tikhaya Sosna River, was 31.4% higher than that of CP 3 on the slopes of the Manjokha River. The average density of generative individuals for the two cenopopulations was 22.1 sp.* $(100 \text{ m}^2)^{-1}$, which is 83.7 % of the total specimen abundance of individuals.

The average density of CP 2, growing in the Tikhaya Posna River floodplain meadow, was 11.8 % lower than that of CP 4 in the Manjokha floodplain meadow, and averaged 31.4 sp.* $(100 \text{ m}^2)^{-1}$ for the two populations.

The density of generative individuals of CP 2, growing in the Tikhaya Posna River floodplain meadow, was 14.9 % higher than that of CP 4 in the Manjokha floodplain meadow. On average for the two cenopopulations, the density of generative individuals was 24.5 sp.* $(100 \text{ m}^2)^{-1}$, which is 81.2 % of the total specimen abundance of individuals.

On average, the density of individuals was higher in cenopopulations growing in floodplains than on chalky slopes by 18.9 %. The density of generative individuals did not differ reliably - the difference was within 4.5 %.

The weight of one fruiting plant of CP 1 growing on the chalky slopes of the Tikhaya Sosna River was 16.9 % higher than that of CP 3 on the slopes of the Manjokha River, and was 285.1 g on average for the two cenopopulations.

The weight of one fruiting plant of CP 2 growing in the floodplain of the Tikhaya Posna River and CP 4 in the Manjokha River floodplain did not differ significantly, and, on average, was 650.4 g for the two populations.

The seed yield per plant of CP 1 growing on the chalky slopes of the Tikhaya Posna River was 10.2 % higher than that of CP 3 on the Manjokha River slopes, and averaged 10.3 g for the two populations.

The seed yield per plant of cenopopulation CP 2 growing on the chalky slopes of the Tikhaya Sosna River was 39.8 % higher than that of cenopopulation CP 4 on the slopes of the Manjokha River, and averaged 20.8 g for the two cenopopulations.

To study the influence of ecological and cenotic habitat factors on the age spectrum, the ontogenetic states of individuals of local *M. falcata* cenopopulations growing in different ecotopes of small river basins were analyzed.

Ontogenetic spectra of populations obtained as a result of long-term observations reflect the dynamic processes occurring in the system "soil-plant-community" in interaction with the ecotope, the course of regeneration and extinction of individuals, indicate the rate of change of generations, successional processes, etc. The predominance of plants of a certain age category in the spectrum reflects the stability of cenopopulations under given ecological conditions. Under optimal growing conditions, cenopopulations are characterized by a normal statistical distribution of ratios of individuals of different ages.

All studied cenopopulations both in floodplains of the Tikhaya Sosna and Manjokha rivers and on slopes were full-member and had a continuum (continuous) character of distribution of individuals by age groups (fig.).

The ontogenetic spectra of *M. falcata* in all the studied phytocenoses have a similar character: the spectra of the four cenopopulations are unilinear, centered, with the predominance of individuals in the late, old generative age state (g3) and in the mature, medium generative age state (g2).

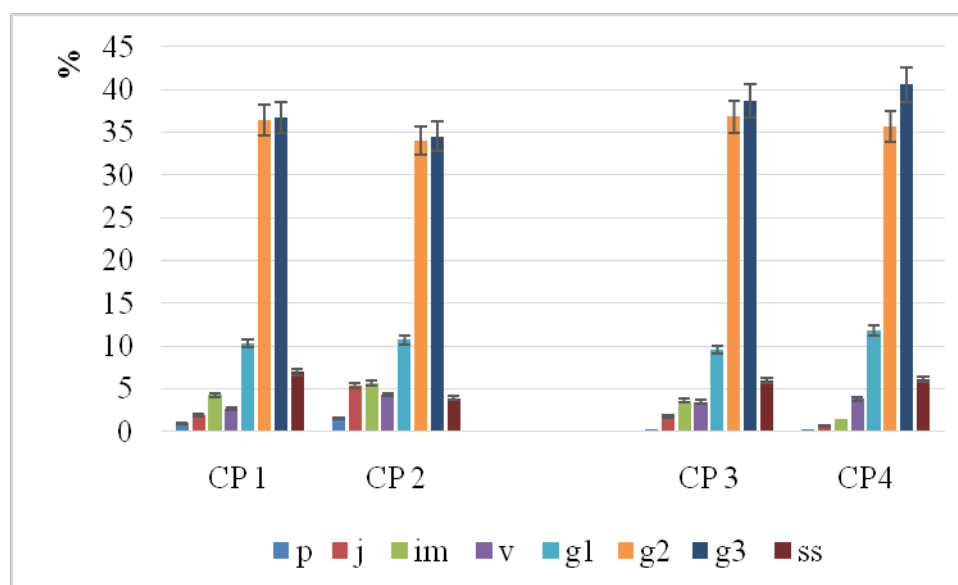


Figure 1. Ontogenetic states of wild populations of *M. falcata* in floodplains and slopes in small river basins of the Cretaceous South of European Russia

Note. *p*-seedlings; *j*-juvenile; *V*-vegetative plants (combined group *im*-immature and *v*-virginile); *g1*-young generative; *g2*-medium generative; *g3*-old generative; *ss*-subsenile

On the slope of the Tikhaya Pine River, the proportion of plants of *g1*-*g3* fractions in the CP 1 cenopopulation was 83.4%; on the slope of the Manjokha River in CP 3, it was 85.01%. In the floodplain meadow of the Tikhaya Sosna River, the proportion of plants of *g1*-*g3* fractions in the CP 2 cenopopulation was 79.17 %, and 88.05 % in the Manjokha River slope in CP 4. The predominance of generative individuals in the ontogenetic spectrum indicates a good ability of *M. falcata* cenopopulations to self-maintenance.

4. Conclusion

1. It was established that the number of individuals (density) of *M. falcata* was on average 18.9 % higher in cenopopulations growing in floodplains than on chalk slopes. The density of generative individuals on the average for all studied cenopopulations was close and varied within the range 81.2-83.7 %. The predominance of generative individuals in cenopopulations indicates their stability in time and high adaptive potential.

2. Evaluation of model plants showed that, on average, the weight of one fruiting plant growing in more favorable conditions of moisture in floodplain meadows was 2.28 times higher than that of plants growing on chalky slopes. Seed yield of plants on floodplain meadows was 2.02 times higher than seed yield of plants growing on chalky slopes.

3. The assessment of age states has shown that the species *M. falcata* forms, both in meadows in floodplains and on chalk slopes, full-member normal cenopopulations, which have a continuous (continuous) distribution of individuals by age groups, stable in time and in space. The centered ontogenetic spectrum indicates the stable status of *M. falcata* cenopopulations in plant communities in various ecotopes of small river basins.

4. Valuable source material for selection of *M. falcata* varieties adapted to different ecotopic conditions has been obtained. Forms adapted to favorable conditions of sufficient moisture have been obtained from cenopopulations of floodplain meadows. From the cenopopulations growing on chalk slopes in unfavorable conditions of limited water resources, the forms able to withstand the conditions of scarce moisture of steppe and arid areas have been selected.

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