Features of the structure and spread of the root system of wild species of legumes and their reaction to the level of groundwater

Ya M Abdushaeva and O V Shtro
Yaroslav-the-Wise Novgorod State University, 41, ul. B.St. Petersburgskaya, Veliky Novgorod, Russian Federation
E-mail: yaroslava-66@mail.ru

Abstract. Improving the feed base in the North-West region is a priority for providing farm animals with complete feeds. Perennial legumes contain nutrients that are necessary to increase the productivity of farm animals and adapted to the soil and climatic conditions of the region. Legume plants in the composition of grass mixtures form high and stable yields, are characterized by intensive growth rates after the next alienation, and are resistant to intensive hay or pasture use. Each plant species has different requirements for the biological characteristics of growth and development to the growing conditions, therefore, monitoring of species is relevant for their further conservation. For the successful realization of the potential capabilities of perennial leguminous plants, it is necessary to effectively use their gene pool of wild and cultivated species that grow in the flora of the Novgorod region. The article studies the biological and economic properties and characterizes perennial leguminous plants for cultivation in the North-West region of Russia. Laws of transformation of matter and energy within the agro-geosystem and methods for their improvement. Plant communities were identified in which perennial leguminous plants grow, which have selection value as a source material for selection. The structural features of root systems, the reaction to the groundwater level were studied, and their ecological plasticity was revealed.

1. Introduction
Perennial leguminous grasses are the source of the green conveyor for harvesting feeds, the precursors for crops, as they leave root and crop residues in the soil and improve soil structure [1, 2, 3]. The soil and climatic conditions of the North-West region make it possible to obtain dry matter productivity from 17.5 to 42 kg/ha for one mowing [4]. The quality of feed depends on the foliage of the plants and the method of harvesting [5].

In the first half of the 20th century, research was conducted on the territory of the Novgorod region to improve natural pastures and hayfields. The first experimental stations appeared and the Novgorod marsh experimental field (1913), the Knyazhodvorsky meadow experiment station (1914) and others were organized. Researchers at the Department of Plant Production of the Institute of Agriculture and Natural Resources of Yaroslav-the-Wise Novgorod State University revealed a positive effect of mineral fertilizers and tillage on increasing the productivity of flood meadows. Based on the study of the biological, ecological, and phytocenotic features of perennial leguminous plants, methods have been developed for using grass stand, which will ensure a smooth supply of green mass during the season.
2. Problem statement
The competitive ability of plants depends on the species, age, habitus of the formation of the aerial mass and the corresponding ecotope. The studied leguminous plants in ecotopes combined biological factors that responded to worsening growing conditions. The competition of plants in natural cenoses is inhibited by the age state of the dominant species, the structure of root systems, and the reaction to the level of groundwater. Leguminous plants under certain conditions have a positive effect when co-growing. The intensity of use of grass stands also affects the change in species composition, since species differ in the intensity of regrowth, palatability and digestibility of feed [6, 7, 8].

3. Research questions
In the article, the author searches for the answer to the following research questions:

- To identify the places of growth of perennial leguminous plants in natural cenoses with high share, and to monitor the state of the population with economically valuable traits;
- Features of the spread of root systems and the reaction to the groundwater level;
- To identify the biological characteristics of the growth and development of legumes and their communities;
- Ways to restore biodiversity in natural conditions of growth and rational use of wild species of legumes in the flora of the Novgorod region.

4. Purpose of the study
The aim of our research was the ecological-biological and adaptive assessment of wild species of leguminous plants, especially the formation of the root system and the scientific rationale for the conservation of flora in the Novgorod region. The data obtained will allow us to identify plant communities in which the studied plants with economically valuable traits grow.

5. Research methods
The object of the study was wild species of leguminous plants growing in natural habitats. The distribution and affiliation of species by floristic regions was studied by the herbarium collections of the Botanical Institute of RAS named after V.L. Komarov (Saint-Petersburg, LE), All-Russian Research Institute of Plant Production named after N.I. Vavilov (WIR), St. Petersburg State University (LECB) in the amount of 3799 sheets and literature data. To determine the types of plants we used the plant identifier by Tsvelev, 2000.

During the period of growth and development of legumes, the morphological features of the root system and root spread in the arable horizon were studied to adapt the species in the ecotope. The botanical composition of the dryland and floodplain meadow of medium moisture level was determined.

6. Findings
Monitoring of species in the flora of the Novgorod region is necessary for the restoration and formation of vegetation cover and their conservation in natural cenoses. The number of adventive plant species with a high competitive ability is increasing annually.

The data obtained indicate that 1308 species grows in Mstinsky, 1232 Nizhne-Lovatsky and 1224 Ilmensky floristic regions with favorable conditions for plant growth and development. The terrain of the above areas contributed to the spread of dry and floodplain meadows of high and medium levels of moisture [9, 10, 11].

An important role for the growth and development of plants belongs to the root system. Earlier studies on root systems were descriptive. The morphological characteristics of the roots and their spread over soil horizons, relationships with soil, and the importance of plant communities in the life activity have not been studied.

Plants of the family Fabaceaerod L. have the rod root system. Plants of Astragalus glycyphyllus L., A. danicus Retz., Lathyrus palustris L., L. sylvestris L., L. vernus L., Vicia cracca L. from the main root
leave numerous bundles with smaller roots in a 15 cm soil layer. The resumption of vegetation in them occurs from the root neck of the main root formed at a depth of 5 cm from the soil surface. The deepening of the root neck into the soil protects the formed buds from being etched by animals, low mowing height and increases resistance to adverse wintering conditions.

In the studied species, we described the root-shoot monoclone *Medicago falcata* L. The roots are distributed evenly in the arable horizon on which buds of regrowth are formed, from which new clones appear.

*Trifolium hybridum* L., *T. repens* L., *T. incarnatum* L., *T. medium* L., *T. spadiceum* L., *Lathyrus pratensis* L., *Vicia cracca* L. the root system is shallow rooted, the main mass of roots develops to a depth of 40-50 cm. These species grow well after mowing, are resistant to trampling.

Species with a deep-rooted root system and well-branched roots which cover the soil and subsoil to a depth of 2 m. *Trifolium montanum* L., *Anthyllis macrocephala* Wend., *Medicago sativa* L., *M. falcata* L., *Lathyrus silvestris* L., *Lotus corniculatus* L., *Melilotus albus* Medc., *M. officinalis* (L.) Pall. grow on well-draining soils and do not tolerate proximity and contact with groundwater.

*Anthyllis macrocephala* Wend. grows in the Mstasa meadow in Borovichi district, in this area there are limestone outcrops. The roots are located in a 10 cm layer of soil and form a dense turf due to numerous root processes (figure 1).

![Figure 1](image)

**Figure 1.** The nature of the spread of the root system of *Anthyllis macrocephala* Wend.

On the sod-carbonate soils of the lake Il’men clint in *Anthyllis macrocephala* Wend plants thickened root penetrates to a depth of 65 cm. Slight branching of about 22% of the mass of roots is noted in the 5 cm soil layer and 65% of the arable horizon. The nature of the spread of roots depends on the botanical composition of the stand, the age of the plants and the projective cover of 65% in the ecotope. Thanks to a well-developed root system, this species forms numerous shoots, satisfactory seed renewal of the population, and high competitive ability.

*Trifolium montanum* L. is a typical mesophyte, its branched rhizomes are located at a depth of 10-12 cm from the soil surface (figure 2). The roots are relatively thick and powerful, less branched and penetrate to a depth of 1 m or more. The root neck in the second year of life is clearly visible and immersed in the soil 3-4 cm. In well-drained areas, roots form in a 10 cm soil layer, and a powerful turf is formed. Species with a durable and solid turf are of anti-erosion value and must be used to root slopes...
The plans Anthyllis macrocephala Wend., Astragalus arenarius L., A. danicus Retz., Trifolium montanum L., T. incarnatum L., Lathyrus sylvestris L., L. vernus L., Medicago falcata L., Melilotus albus Medic, M. officinalis (L.) Pall. with deeply penetrating roots were distinguished by low leafiness, thick pubescent stems.

Plants of Vicia cracca L. are with a well-developed stem root, branching rhizomes and short shoots. Rhizomes are formed at a depth of 5-7 cm in the soil. From the horizontal rhizomes, new individuals are formed that form thin, well-developed above-ground shoots and well-developed turf. The main root of Vicia cracca L. penetrates to a depth of 35-60 cm (figure 3).

Medicago falcata L. has a well-developed root system with a thick root neck growing on sod-carbonate soils. The roots are horizontal, then deepen and become sinuous (figure 4).
The formed lateral roots of the first order are well branched, short with thin roots. In the ecotope of the average level of moisture in the Shelon and Msta meadows, this ecotype is characterized by root shoot with the help of which a self-clone is formed.

Perennial leguminous plants growing in natural cenoses reacted differently to the level of groundwater. In areas with temporary flooding and proximity and contact with groundwater, species with a finely rooting root system grow well.

In floodplain meadows and meadows with high humidity soils are characterized by a high humus content and *Lathyrus pratensis* L., *Trifolium hybridum* L., *Vicia cracca* L. grow. The above species make up more than 62% of the legume component in the grass of the meadow, located along the banks of the Volkhov River.

The Shelon meadows of medium moisture level grow *Trifolium hybridum* L., *T. repens* L., *T. pratense* L., *Medicago varia* L., *M. lupulina* L., *Lotus corniculatus* L.

The floodplain ecotype *Lathyrus palustris* L. tolerates a prolonged flood and forms a high yield of green mass.

Floodplain ecotypes of medium moisture *Trifolium hybridum* L., *Lotus corniculatus* L. are moderately resistant to flooding and grow on soils with high sludge content.

Fallow ecotype *Trifolium repens* L., ecotype of salt shallows *T. fragiferum* L., and meadow-mesophytic ecotypes *Medicago varia* L., *M. lupulina* L., *Lotus corniculatus* L. are unstable to flooding and close standing groundwater.

According to the results of the studies, it was found that the spread of root systems in leguminous plants in natural cenoses depends on the soil of its physical and chemical properties, and the thickness of the humus horizon. The high productivity of the grass stand directly depends on the spread of roots along the soil horizons, as well as morphological characteristics and biological characteristics of plants.
7. Conclusion

- Trifolium repens L., Medicago lupulina L. (fallow ecotype), Lotus corniculatus L. (meadow-mesophytic ecotype), Astragalus danicus Retz. belong to finely rooting species, form a powerful, continuous turf, their grass stands are resistant to grazing and mowing. These species can be used to create pastures and lawns.
- Meadow-mesophytic ecotypes growing in the Msta meadows had roots which spread uniformly along the vertical and horizontal soil horizons and formed highly productive grass stands.
- On meadows of medium moisture level located on the banks of the Sheloni and Msta meadows, root shoot plants are described Medicago falcata L.

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