The influence of treatment methods on agrophysical soil properties and old Eastern galega stand root development

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Abstract. All mechanical effects are primarily aimed at improving soil conditions and the root system. Different treatment methods with different types of working organs affect the fractional composition of particles, agrophysical soil properties, and the ability to restore the root system of old-age, degraded stands of perennial grasses with a root-shoot root system. The article presents data on the results of three field experiments (2017–2019). An analysis of the fractional composition of soil with various cultivation methods was carried out, and the relationship between the number of first-order roots of the eastern goat grass stand and agrophysical soil properties was identified. The maximum soil fraction was 7 and 10 mm when treating with a BDT aggregate in one track, the minimum percentage was observed when treating with a Leader aggregate in two tracks to a depth of 10–12 and 16–18 cm. The greatest “clumpiness” of fractions was revealed with a smaller number of treatments. The optimal soil conditions for the growth and development of the root system of old-age goat grass stands in the 0–20 cm layer were established during flat cutting. By the end of the growing season, the number of first-order roots increased from 15,000 to 22,000 thousand units/ha

1. Introduction

Eastern galega is a relatively new fodder crop for the Middle Urals. The study started in 1925. A.A. Khrebtovym began to study it on the basis of the botanical garden of Perm University. The first studies of agrotechnological parameters were carried out in the late 1950s – early 1960s. Galega was introduced for production in the early 1990's by N.A. Khalezov, A.V. Goryntsev, L.V. Falaleeva, E.V. Balandina. Currently, the field of research can be described as “optimization of the use of grass stand”, which includes treatment issues (M.A. Nechunaev, M.Yu. Satarov, V.V. Khristich, Eusun Han, Timo Kautz, Ute Perkons, Marcel Lüsebrink, Ralf Pude, Ulrich Köpke, Michelle Oldham, Corey V. Ransom Goatsrue), optimization of mini-nutrition (A.A. Vasina, V.G. Chugunov, I.V. Karpova) and individual selection of the strain of microorganisms (A.L. Kokorina, O.G. Rapina, Seppo Kajalainen, Michael Schroda, Kristina Lindström) [1–3].

In the current economic conditions, it is very advantageous to restore the productivity and longevity of old-age stands of perennial grasses. Grass stands become thinned, which deteriorates agrophysical, agrobiological indicators and land productivity. Although this crop has a high longevity, it can be grown for more than 10 years and give stable and high yields of seeds or green mass, with a minimum ripening time. In the Urals, it begins to actively vegetate immediately after snow melting, using melt water and spring rainfall, shading weed plants, which is comparable to winter crops. It can be mowed twice for100–120 days with a green mass yield of up to 60 t/ha. Seed productivity is up to...
8 kg/ha in 100–110 days, which makes this crop multi-purpose [9]. Indeed, perennial leguminous herbs have a wide range of applications for feed production, production of silage, green fodder, grass meal, hay, grazing [5]. They also participate in the reproduction of organic substances, leaving root residues with a high content of nitrogen and nitrogen-fixing microorganisms, which contributes to the structuring and preservation of fertility. Most legumes are characterized by an average longevity of 6–8 years, which limits the economic suitability of grass stands [4]. However, taking into account the biology of the grass, it is possible to reanimate old bean agrophytocenoses, mechanically improving soil conditions, thereby activating the growth of first-order roots. The root allows the use of various treatment systems to increase longevity and productivity of forage lands, which will have an economic effect when cultivating perennial leguminous grasses and increase the period of land use without costs of new grass planting [7, 8]. The study of root formation in forage grasses with different root systems will allow us to adjust and obtain target production indicators for production.

2. Materials and methods
Since 1997, on the field of Perm State Agrotechnical university, long-term field experiments have been conducted to restore 15–18-aged and degraded stands of leguminous perennial grasses. The soil typical of Perm Territory is soddy-finely podzolic, heavy loamy with a low humus content (2.2%), and a slightly acidic soil solution of 5.3.

The article presents data on the results of three field experiments (2017, 2018, 2019). The treatment of old-age stands of Eastern galega was carried out according to the following scheme: A1 – without treatment, (control), A2 – one-track disking, A3 – two-track disking, A4 – one-track plane-cutting to a depth of 10–12 cm, A5 – two-track plane-cutting to a depth of 10–12 cm, A6 – one-track plane cutting to a depth of 16–18 cm, A7 – two-track plane cutting to a depth of 16–18 cm. Disk treatment was carried out by the BDT aggregate to a depth of 12–14 cm, plane cutting was carried out by a combined tillage aggregate "Leader". These tools have different working bodies and a different way of acting on the root system and soil. Grass stands were treated in the second decade of May. A fractional analysis of soil was carried out immediately after grass stand treatment. The number of first-order roots was determined by washing out the monolith. Harvesting was carried out in the phases of budding, flowering, first mowing (25.06), and second mowing (05.08.) by the sheaf method.

3. Results and discussion
Due to the strong bonds within the aggregates, the soil is represented by a crumbly grain-like aggregated substance rather than a monolithic piece. It is responsible for the influence of external factors on the soil. A decrease in density increases porosity, moisture penetration, gas exchange. For a quantitative assessment, it is necessary to pay attention to the fractional composition of aggregates presented in Figure 1. Let us consider valuable aggregates ranging in size from 10 to 0.25 mm. The “gravel” fraction of 2–10 mm in size has the following properties: it is not able to swell, it does not form soil capillaries, and it reduces moisture capacity. Considering the fractional composition after various types of treatment shown in Figure 1, the maximum fraction of 7 and 10 mm in size was when treating by BDT in one track – 23.4 and 22.6 %, while in the control experiment, it was 13.6 %. The minimum percent ratio was observed when treating by Leader in two tracks to a depth of 10–12 and 16–18 cm – 2.1; 5.9; 6.2 %.

In fractions of more than 3 mm, namely 10, 7 and 5 mm, there is a trend to form more fractions of gravel – 23.4; 16.4; 19.9 %, than when treating in two tracks – 8; 2.1; 10.8 %, respectively; in the inverse relationship for fractions of less than 0.25 to 2 mm in size, the double percent ratio prevails. This is also confirmed by Figure 2 when “gravel” and sand fractions are considered.
The greatest “lumpiness” of fractions was revealed under a smaller number of treatments – 77.4; 77 91.4 and 66; 69.2; 82.1 % – under double treatments, and a larger fraction of 0.25–2 mm – 30.8 and 34 % compared with the control experiment – 22.2 % and under the disking treatment – 17.9 %. Thus, disking does not ensure high-quality crumbling in comparison with lancet working bodies, which could not but affect the agrophic indicators of soil shown in Figure 3.
Flat cutting positively affected the porosity of soil aeration which increased until one mowing – 06.25, which indicates the growth of the root system. Under the double treatment, all variants increased the aeration porosity compared to a single treatment [6]. Throughout the growing season, the treated options had higher rates compared to the control option. Treating with a double-track plane cutter to a depth of 16–18 cm and disking in two tracks were more efficient in all decades since June 5, which indicates a deep and severe destruction of the layer of perennial grasses of 40 and 47 %. Flat cutting in one track at different depths is also efficient. Thus, more optimal soil conditions are created in a layer of 0–20 cm, for the growth and development of the root system, with a larger and more frequent soil cultivation (Figure 4).

The number of first-order roots on the untouched grass stand ranged from 9000 to 16000 thousand units/ha. This number of structural roots can be increased with the help of sleeping growth points on the root system. In this case, young roots appear even on the old, very lignified parts of the root, if there are favorable conditions. At the beginning of the study, the number of first-order roots ranged from 6,000 to 18,000 thousand units/ha. At the beginning of flowering, nutrients were redistributed, which decreased the number of structural roots to 4000–11000 thousand units/ha. After the first mowing (06.25.), the growth of roots was intensive due to the growth of the aboveground mass and the need to nourish it.

A similar trend was observed before the second mowing (05.08.). Considering the dynamics of the root system regrowth, it follows that the formation of a well-developed root system in a short time is possible with flat cutting. By the end of the growing season, the number of first-order roots increased from 15,000 to 22,000 thousand units/ha. In perennial plants, by the onset of cold weather, a significant part of fouling roots died, and wintering roots performed two tasks: they preserved nutrient reserves and contributed to the renewal of the root system [6]. Consequently, an increase in the number of first-order roots contributes to an increase in the area of nutrition, better wintering due to a larger number of reserve nutrients, and the early growth of grass stand.
Figure 4. The influence of grass rejuvenation on the number of first-order roots, thousand pieces/ha

4. Conclusion
1. When treating in one track, there were more fractions of “gravel” which were of 3 mm, namely 10, 7 and 5 mm – 23.4; 16.4; 19.9 % than when treating in two tracks – 8; 2.1; 10.8%, respectively, and for fractions of less than 0.25 to 2 mm, where the percentage prevails under the double treatment, the relation is reverse;
2. Under the frequent cultivation, more optimal soil conditions are created in the 0–20 cm layer for the growth and development of the root system of old-age Eastern galega stands;
3. By the end of the growing season, the number of first-order roots increased from 15,000 to 22,000 thousand units/ha. An increase in the number of first-order roots on degraded legume agrophytocenoses contributes to an increase in the nutrition area and better overwintering due to a larger amount of reserve nutrients, and early growth of grass stand.

References
[1] Han E, Kautz T, Perkons U, Lüsebrink M, Pude R and Köpke U 2015 Quantification of soil biopore density after perennial fodder cropping Plant and Soil 394 73–85
[2] Oldham M and Ransom C V 2017 Goatsrue (Galega officinalis) Response to Herbicides Weed Technol. 1 70–76
[3] Kaijalainen S, Schroda M and Lindström K 2002 Cloning of nodule-specific cDNAs of Galega orientalis Physiol. Plantarum 4 588–593
[4] Zubarev Yu N, Falaleeva L V, Nechunaev M A and Fotina O V 2016 Influence of tillage techniques for old-age galegaorientalis grass stand on agro-physical and microbiological indicators of soil in middle Preduralie (Russia) Agrofor. 1 167–171
[5] Vasina A A, Chugunov V G and Karpova I V 2015 The influence of rejuvenation techniques on an old-growth herbaceous goat grass, in: Actual problems of agricultural science and ways to solve them (Kinel: RICA of the AGRA) pp 7–12
[6] Zubarev Yu N, Falaleeva L V and Nechunaev M A 2016 The influence of rejuvenation techniques on the formation of root offspring of an old grass stand of eastern goatskin in the Middle Urals Perm Agrarian Bull. 2(14) 28–34
[7] Kokorina A L and Rapina O G 2018 Eastern goatskin productivity depending on the use of bacterial preparations on old-age grass stands in the conditions of the Leningrad Region Bull. of the St. Petersburgh State Agrarian Univer. 2(51) 23–27
[8] Satarov M Yu 2014 The optimal mode of use of the old grass stand of the eastern goatskin, in:
Land reform and land use efficiency in the agricultural sector of the economy (Ufa: World of the Press) pp 351–354

[9] Khristich V V 2013 Seed productivity of Eastern goatskin, depending on the methods of rejuvenation of grass stand, in: Innovative development of the agriculture of the northern Trans-Urals (Tyumen: Rizograf) pp 136–139