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INFLUENCE OF TILLAGE TECHNIQUES FOR OLD-AGE GALEGA ORIENTALIS GRASS STAND ON AGRO-PHYSICAL AND MICROBIOLOGICAL INDICATORS OF SOIL IN MIDDLE PREDURALIE (RUSSIA)

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ABSTRACT

The paper presents the results of investigations conducted in 2013 on the experimental and training field of the Perm State Agricultural Academy with the aim to reveal the influence of rejuvenation agro-techniques for perennial grass stands on thickening processes in sod-podzolic soils of Middle Preduralie (Russia). The authors consider dependence of grass stand thinning on different tillage techniques, give data on calculating illumination, light brightness and air temperature in ground surface layer. As investigation object was used partly thinned 13 year old galega orientalis grass stand which is considered to be inapplicable for large scale production. Conducted investigations revealed the dynamics of root system recovery of old-age galega orientalis grass stands for subsequent involvement of degraded grass stands into production with sustainable green mass yield and to produce seeds. Under influence of different rejuvenation techniques the illumination of grass stand changed and as a result growth conditions altered. That leads to alteration in agro-physical and agro-biological factors that favor yield formation. Implemented techniques improved illumination and permeability of sun radiation to the soil surface that increases soil temperature and favorably influences the symbiosis of legumes with resistant microorganisms and root system growth. Root system entirely covers arable layer structuring it, increases the area for nutrition as well as decreases heavy clay soils overcrust creating optimal conditions for growth of nitrogen fixing microorganisms and development of perennial legume grasses. This technology is energy saving and leads to cost reduction and increase of profitability.

Keywords: *old-age grass stands, galega orientalis, rejuvenation, illumination, soil temperature*

INTRODUCTION

In Middle Preduralie, perennial legume grasses take large areas and play a significant role in increase of productivity of arable land and in increase of production of fodder with high protein content and balanced nutritional qualities.

Traditional for the Urals grasses are meadow clover and lucerne which represent the only source of plant protein in the region. Scientific research and best production practices already proved possibility to cultivate in Middle Preduralie soboliferous grass – galega orientalis, which as ecologically flexible plant easily fits to regional agro-climatic conditions and forms high yields (Ganzhara et al., 2002; Zubarev, 2003). In Permskii krai there exist lots of areas of old-age perennial legume grasses and their grass mixtures with cereals that can be rejuvenated (Zubarev et al., 2003). However, this issue requires more detailed study and development of a practical rejuvenation technique of grass stand in production and in science in general.

MATERIALS AND METHODS

In the field experiment, rejuvenation of perennial legume grasses was implemented mechanically on the experimental and training field of the Perm State Agricultural Academy in 2013. Agro-technique in the experiment complies with scientific system of agriculture recommended for Middle Preduralie. Disking of soil was done by the heavy disc harrow BDT-3, subsurface cultivating – by the combined subsurface unit APK “Leader – 4” in the beginning of vegetation in 2013. Partly thinned 13 year old grass stand of galega orientalis was used as investigation object. The experiment was on sod-not deep podzolic middle loamy soil with the arable layer 0-24 cm. The experiment scheme was as following: 1 – control (untapped grass stand); 2 – one-track disking; 3 – two-track disking; 4 – one-track subsurface cultivating at 10 – 12 cm; 5 – two-track subsurface cultivating at 10 – 12 cm; 6 – one-track subsurface cultivating at 16 – 18 cm; 7 – two-track subsurface cultivating at 16 – 18 cm.

RESULTS AND DISCUSSIONS

Immeasurably huge amount of light energy provided for the earth by the sun enables presupposing that plants do not lack for it. However, some investigations show that plants are not always provided with enough light, and light energy is partly used by plants and not always reaches soil surface (Shein, 2006; Kholzakov, 2006). It is possible to influence this factor and develop appropriate technological methods to reveal optimal illumination, volume of sun light at soil surface and in rhizosphere of old-age grass stands (Revut, 1964, Doyarenko, 1966). Thus, various agro-techniques of rejuvenation of old-age galega orientalis grass stand affected agro-physical soil properties differently (Table 1).

Table 1. Influence of tillage techniques for old-age galega orientalis grass stand on agro-physical and microbiological properties of soil in the Middle Preduralie (First mowing – 25 June, phenological phase – blossoming)

Tillage	Air temperature in rhizosphere, ^{o}C		Air humidity in rhizosphere, %		Illumination of grass stand in rhizosphere, Lux		Microbiological activity of soil, % (June)	
	^{o}C	Deviation, %	%	Deviation, %	Lux	Deviation, %	0-10 cm, %	10-20 cm, %
Control	25.6	-	42.3	-	2520	-	17.07	20.67
BDT, one track	25.8	+0.2	40.8	-1.5	7100	+4580	28.35	47.03
BDT, two tracks	25.7	+0.1	47.4	+5.1	5800	+3280	38.88	53.00
Leader, one track, at 10 – 12 cm	26.0	+0.4	43.8	+1.5	7070	+4550	26.38	36.48
Leader, two tracks, at 10 – 12 cm	26.5	+0.9	51.6	+9.3	5800	+3280	31.16	47.41
Leader, one track, at 16 - 18 cm	25.8	+0.2	51.8	+9.5	7100	+4580	20.01	37.94
Leader, two tracks, at 16– 18 cm	26.5	+0.9	51.8	+9.5	5070	+2550	39.44	54.14

In the control variant the temperature in rhizosphere constituted 25.6 ^{o}C, while air temperature on the open part of the field constituted 26.5 ^{o}C. According to the data of a number of authors, it is supposed that loose soil reflects sun rays in a less degree than smooth soil thanks to bigger surface and smaller reflection ability (Doyarenko, 1966). Based on the data it can be concluded that double subsurface cultivating of grass stand by means of the unit "Leader-4" at different depths had maximum temperature in rhizosphere – 26.5 ^{o}C that is by 0.9 ^{o}C higher than control. However, all tillage implemented in one track at different depths by means of different units varied from 25.8-26.0 ^{o}C that is by 0.2 – 0.4 ^{o}C higher. Soil temperature quite complicated affects the velocity of water income into soil, plants, roots and rate of transpiration. It is the result of the fact that at temperature decrease fast water income into plant is impossible, as at 0 ^{o}C ability to abstract water constitutes from $^{1}/_{3}$ to $^{1}/_{2}$ of this value at 25 ^{o}C. Water viscosity increases and as a consequence of this water income decreases not only from soil into roots but also its movement in root decreases while temperature decreasing (Revut, 1964; Doyarenko, 1966). Considering air humidity in rhizosphere we revealed that due to better penetration of sun radiation and light soil temperature decreases to 26.5 ^{o}C, and as a consequence evaporative ability of soil increases, as well as transpiration – thanks to bigger water income, that increases air humidity in rhizosphere to 51.8 % by tillage with the unit "Leader – 4" at a depth of 16 – 18 cm with different intensity. High air humidity was also at double tillage of grass stand by the unit BDT-3 and subsurface cultivator "Leader-4" at a depth of 10 – 12 cm, 47.4 and 51.6 %, respectively. Thus, it can be concluded that bigger depth of arable layer and increase in number of tillage raise humidity of rhizosphere of grass stand by

5.1 – 9.5 %. Tillage affected illumination of grass stand in rhizosphere. At one-track tillage by different units, illumination amounted 7100 lux. When the number of tillage at lower depths raises, illumination decreases to 5800 lux due to more intensive growth of above ground mass and increase in the number of stalks. However, two-track tillage at a depth of 16 – 18 cm decreased illumination to 5070 lux in comparison with other variants but had twice higher illumination of grass stand in comparison to control 2520 lux. Thus, application of different tillage techniques increases illumination in rhizosphere and as a consequence determines optimal grass stand density.

Biological activity of organisms play an important role in soil, mainly for decomposition of organic matter in soil and especially of plant rests. Thus, in June 2013 cellulose activity of arable horizon in soil layer 0 – 10 cm varied from 17.07 до 39.44 %. The highest tissue decomposition percentage was in variants with two-track tillage by means of the unit BDT and the unit "Leader – 4" at a depth of 10 – 12 cm and 16 – 18 cm and varied from 31.16 to 39.44 %. In variants with single tillage, microbiological activity was 20.01 – 28.35 %. The lowest cellulose activity constituted 17.07 % in the variant with untapped grass stand. In the layer 10 – 20 cm the highest cellulose activity was from 47.41 to 54.14 % in the variants with double tillage at different depths. Activity of microorganisms in the layer 10 – 20 cm is by 15 – 17.93 % higher in comparison with the layer 0 – 10 cm. The variants with one-track tillage at a different depth varied from 36.48 to 47.03 %.

The lowest percentage of activity of microorganisms was observed in untapped grass stand and constituted 20.67, that is by 3.6 % higher than in the layer 0 – 10 cm. Microbiological activity in the layer 20 – 20 cm is higher than in the layer 0 – 10 cm in all variants of tillage; microbiological activity is observed in variants with bigger number of tillage and bigger depth of tillage.

CONCLUSIONS

To recover the productivity of old-age galega orientalis grass stand it would be recommended to implement two-track tillage by means of different units with various working elements (disks, subsurface blade) that provides more intensive cutting and loosening of furrow slice. The tillage enable forming more favorable agro-physical conditions, optimal intake of sun radiation into soil and illumination of grass stand generally, hence microbiological activity of nitrogen fixing microorganisms increases. From economical point of view the most profitable is the variant with the two-track tillage of grass stand by means of the unit "Leader – 4" at a depth of 10-12 cm, that enables creating mentioned above conditions with least expenditures.

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