The Role Of Perennial Grasses In The Accumulation Of Organic Matter In Soil-Saving Agriculture

THE ROLE OF PERENNIAL GRASSES IN THE ACCUMULATION OF ORGANIC MATTER IN SOIL-SAVING AGRICULTURE

V I Cherniavskih[1,2], E V Dumacheva[1,2], M N Marinich[3], L D Sajfutdinova[3]

[1]All-Russian Research Institute of Phytopathology, 5 Ownership, Institute St., r.p. Big Vyazemy, Odintsovo district, Moscow region, 143050, Russia
[2]Federal Williams Research Center of Forage Production & Agroecology, 1 building, Scientific town, Lobnya, Moscow region, 141055, Russia
[3]Belgorod State University, 85, Pobedy St., Belgorod, 308015, Russia

E-mail: cherniavskih@mail.ru

Abstract. In the farms of the Belgorod region, a comprehensive study was conducted to assess the productivity of perennial grasses using soil-saving technologies in comparison with traditional methods of tillage. The results of the dispersion analysis showed that the value of the indicator of the total aboveground and underground productivity of perennial grasses significantly depends on the species composition of the grass stand. It was found that the difference between the site of a perennial fallow and fields with perennial grasses with the use of soil-saving technologies did not exceed 13.9% in terms of the total aboveground productivity. The aboveground productivity of alfalfa was significantly higher than in the control variant (fallow field) and in the experimental fields with soil conservation technologies – by 73.6 % and 101.6 %, respectively. The accumulation of underground mass in the fallow area and in areas using soil conservation technologies is approximately at the same level – 1.91 kg*(m) $^{-2}$ in the control and 1.85-2.25 (average 2.04) kg*(m) $^{-2}$ in soil-saving crop rotations. At the same time, the Cv in the control variant was 15.78 %, and in grass mixtures, respectively, it was at the level of 16.47 %; 18.74 % and 18.08 %. In alfalfa crops, the accumulation of mass in the underground layer was inferior to the control variant by an average of 27.2 %, and to soil conservation technologies-by an average of 31.9 %. Alfalfa crops, providing greater aboveground productivity, are more intensive in terms of production, but less effective means of increasing the content of organic matter in the soil compared to cereal-legume grass mixtures. In soil conservation agriculture, it is necessary to use cereal-legume grass mixtures as more natural-like, and to increase the intensification of agricultural production, alfalfa crops should be used.
Keywords: multicomponent grass mixtures, organic matter accumulation, soil protection, productivity, dispersion analysis, alfalfa, *Medicago varia*.

1. Introduction

Restoring or reproducing the level of organic matter in the soil is the main challenge of modern agricultural production. The main direction of solving the problem can be an increase in the volume of phytomass returned to the soil, and the restoration of scientifically-based crop rotations as the basis for biologization and increasing the biodiversity of agroecosystems. Crop rotation is the most important

way to biologize, stabilize production, and increase its stability, especially with the use of perennial grasses [1-5].

Vegetation and its soil protection capacity play a crucial role in the process of restoring soil fertility. This question is well covered in the literature [6-9].

It is convincingly shown that agricultural crops have different soil protection capacity, as well as different dynamics of the growth of underground and aboveground phytomass. The share of participation of different types of perennial grasses in this process is also different [10-15].

The analysis of the world experience in the last 10-15 years of using no-till and mini-till tillage systems conducted by the country's leading scientists has shown that crop rotations with long rotation and measures to preserve plant residues in the soil remain effective [16].

Restoring or reproducing the level of organic matter in the soil is the main challenge of modern agricultural production. The main direction of solving the problem can be an increase in the volume of phytomass returned to the soil, and the restoration of scientifically-based crop rotations as the basis for biologization and increasing the biodiversity of agroecosystems. Crop rotation is the most important way to biologize, stabilize production, and increase its sustainability [17].

Due to the urgency of the problem, a study was conducted to assess the productivity of perennial grasses using soil-saving technologies in comparison with traditional methods of tillage.

The aim of the work was to conduct a set of studies to assess the productivity of perennial grasses using soil-saving technologies in comparison with traditional methods of tillage.

2. Methods and materials

According to the cartographic material presented to the developers by the Department of Agro-Industrial Complex and Environmental Reproduction of the Belgorod Region, stationary points were allocated to study the species composition in the crops of herb mixtures of perennial grasses in areas where soil-saving technologies are used. The composition of perennial grasses included varieties of red fescue 'Veselka', 'Iskrinka' and reed fescue 'Willow', 'Alder' and 'Darina‘, ryegrass pasture’ Steppe' and other types and varieties of perennial grasses. The three fields under study are part of “Meat Farms- Iskra” LLC.

Alfalfa crops (*Medicago varia* L.), cultivated according to traditional technologies, are part of LLC "Agroholding Korochansky". In the experiments, alfalfa of the zoned varieties ‘Krasnoyaruzhskaya 1’ and ‘Krasnoyaruzhskaya 2 ' was studied [18].

As an absolute control, a site located near the studied soil-saving crop rotation and representing a long-term deposit with an intact natural community was taken.

Reference designation:

1 FF (control) – fallow field (control);
2 CM 1– cereal mixture – 1 field;
3 CM 2 – cereal grass mix – 2 field;
4 CM 3 – cereal-legume grass mixture – 3 field;
5 MV 1 – M. varia –1 field;
6 MV 2 – M. varia – 2 field;
7 MV 3 – M. varia – 3 field.

The standard indicators characterizing the productivity of aboveground and underground phytomass were determined. In the experiments, 2 mowing was carried out, the productivity of the aboveground mass, the mass of leaf litter, including moss, and the total aboveground mass were determined. In the soil layer of 0-20 cm, the underground mass was determined, the ratio of the productivity of the underground and aboveground mass was estimated, and the total (total) productivity of the aboveground and underground mass was determined. Statistical processing of the results was carried out using formulas for calculating the arithmetic mean, the error of the mean, and the coefficient of variation [19].

3. Results and discussion

The aboveground phytomass of perennial grasses was estimated using soil-saving technologies in comparison with traditional methods of tillage and long-term fallow.

It was found that the difference in the total aboveground productivity between the site of a perennial fallow and fields with perennial grasses using soil-saving technologies did not exceed 13.9 %, which was within the error of the experiment. At the same time, the Cv for the control variant was at the level of 9.37 %. In the CM 1 – CM 3 variants, the coefficient of variation (Cv) was, respectively 7.09 %; 6.01 %; 10.15 %).

The aboveground productivity of alfalfa in variants MV 1-MV 3 was on average significantly higher than in the control variant ZA (k) and in the experimental fields CM 1 – CM 3 – by 73.6% and 101.6%, respectively. The coefficient of variation for the indicator in the variants MV 1 – MV 3 was 6.50%, 9.93%, and 6.46%, respectively.

The results of the dispersion analysis of the total aboveground productivity of perennial grasses using soil-saving technologies in comparison with traditional methods of tillage are shown in Table 1.

Table 1. Results of the dispersion analysis of aboveground productivity of perennial grasses when using soil-saving technologies in comparison with traditional methods of tillage

Source of variation	D	n-1	s^2	F_f	$F_{st\ 0.05}$	h^2_x
General	8.97	69.00	-	-	-	100.00
Repetition	0.05	9.00	-	-	-	0.58
Options	8.66	6.00	1.44	297.14	2.30	96.50
Random factors	0.26	54.00	0.00	-	-	2.92

Note. *D is the sum of the squared deviations (deviant); s2 is the dispersion; n-1 is the number of degrees of freedom; h2x - force of influence on the effective attribute.*

The value of the indicator of the total aboveground productivity of perennial grasses significantly depends on the species composition of the grass stand. For the studied indicator of aboveground productivity of phytomass A, the actual value is greater than the theoretical value, which does not reject the null hypothesis and indicates a significant significant difference between the variants studied in the experiments.

The assessment of the aboveground productivity of cereal-legume grass mixtures, alfalfa and fallow areas showed that the alfalfa crop in the conditions of 2020 provided greater aboveground productivity in comparison with cereal-legume grass mixtures and fallow areas.

The assessment of underground productivity showed that the accumulation of underground mass in the fallow area and in the CM 1 – CM 3 plots is approximately at the same level – 1.91 kg/m^2 in the control and 1.85 – 2.25 (on average 2.04) kg / m^2 in soil-saving crop rotations. At the same time, the Cv in the control variant was 15.78 %, and in grass mixtures (CM 1, CM 2 and CM 3), respectively, it was at the level of 16.47 %; 18.74 % and 18.08 %.

In alfalfa crops, the accumulation of mass in the underground layer was inferior to the control variant by an average of 27.2 %, and to grass mixtures-by an average of 31.9 %. At the same time, the Cv of the underground productivity index for alfalfa according to the variants was 4.90 %; 9.66 % and 8.85 %, respectively.

An important indicator of the formation of organic matter in the crops of perennial grasses is the ratio between the amount of underground and aboveground mass.

In particular, in the case of a fallow area, it was the maximum of 6.26 at the level of Cv = 19.69 %.

On the plots with grass mixtures in the system of soil-saving technologies, it averaged 3.62 (Cv for the variants 18.35 %; 19.22%; 19.76 %, respectively).

In alfalfa fields with the traditional method of tillage, the ratio between the amount of underground and aboveground mass was significantly lower – 5.35 times compared to the control and 3.09 times compared to grass mixtures, and averaged 1.17 (Cv for the variants 3.72 %; 10.60%; 9.71 %, respectively).

As a result, the total indicator of the total productivity of grass stands in all the studied variants – long-term fallow, crops of grass mixtures and alfalfa, was close in value.

In the control area, the mass of the first mowing was 0.27, the second – 0.05 kg / m^2 dry matter (coefficient of variation (Cv) - 22.69 % and 22.67 %, respectively). The following results were obtained in the experimental plots of grass mixtures: CM 1-0.55 and 0.07 kg / m^2 dry matter (Cv = 8.06 % and 19.73 %); CM 2-0.49 and 0.07 kg / m^2 dry matter (Cv = 4.58 % and 9.01 %); CM 3-0.45 and 0.08 kg / m^2 dry matter (Cv = 11.49 % and 10.95%).

When assessing the aboveground productivity of alfalfa, the following results were obtained: in the MV 1 variant, the mass of the first mowing was 0.83, the second – 0.34 kg/m^2 dry matter (Cv = 9.33 % and 15.23 %); in the variant MV 2-0.84 and 0.32 kg / m^2 dry matter (Cv = 9.33 % and 15.23 %); in the variant MV 3-0.89 and 0.35 kg / m^2 dry matter (Cv = 9.87 % and 19.78%).

The results of the dispersion analysis of underground productivity, perennial grasses using soil-saving technologies in comparison with traditional methods of tillage and long-term fallow are shown in Table 2.

Table 2. Results of the dispersion analysis of underground productivity of perennial grasses when using soil-saving technologies in comparison with traditional methods of tillage

Source of variation	D	n-1	s^2	F_f	$F_{st\ 0.05}$	h^2_x
General	12.16	69.00	-	-	-	100.00
Repetition	1.50	9.00	-	-	-	12.37
Options	7.46	6.00	1.24	20.96	2.30	61.31
Random factors	3.20	54.00	0.06	-	-	26.33

Note. *D is the sum of the squared deviations (deviant); s2 is the dispersion; n-1 is the number of degrees of freedom; h2x - force of influence on the effective attribute.*

It is shown that the value of the indicator of underground productivity of perennial grasses significantly depends on the species composition of the grass stand. The strength of the influence of factors on the resulting attribute changes in the series: variants (species composition of the grass stand) → random factors → repetitions (conditions of a separate field).

For the studied indicator of underground productivity, the actual value is greater than the theoretical value, which does not reject the null hypothesis and indicates a significant significant difference between the studied variants.

The results of the dispersion analysis of the ratio of underground and aboveground mass, perennial grasses when using soil-saving technologies in comparison with traditional methods of tillage are shown in Table 3.

Table 3. Results of the dispersion analysis of the ratio of the underground and aboveground mass of perennial grasses when using soil-saving technologies in comparison with traditional methods of tillage

Source of variation	D	n-1	s^2	F_f	$F_{st\ 0.05}$	h^2_x
General	250.51	69.00	-	-	-	100.00
Repetition	7.84	9.00	-	-	-	3.13

Options	223.35	6.00	37.23	104.06	2.30	89.16
Random factors	19.32	54.00	0.36	-	-	7.71

Note. *D is the sum of the squared deviations (deviant); s2 is the dispersion; n-1 is the number of degrees of freedom; h2x - force of influence on the effective attribute.*

It is shown that the value of the ratio of the underground and aboveground mass of perennial grasses significantly depends on the species composition of the grass stand. The strength of the influence of factors on the resulting attribute changes in the series: variants (species composition of the grass stand) → random factors → repetitions (conditions of a separate field).

For the studied indicator of the ratio of underground and aboveground mass, the actual value is greater than the theoretical value, which does not reject the null hypothesis and indicates a significant significant difference between the variants depending on the species composition of the grass stand.

The results of the dispersion analysis of the indicator of the total (total) productivity of aboveground and underground phytomass of perennial grasses using soil-saving technologies in comparison with traditional methods of tillage are shown in Table 4.

Table 4. Results of the dispersion analysis of the total productivity of aboveground and underground mass of perennial grasses using soil-saving technologies in comparison with traditional methods of tillage

Source of variation	D	n-1	s^2	F_f	$F_{st\ 0.05}$	h^2_x
General	6.13	69.00	-	-	-	100.00
Repetition	1.41	9.00	-	-	-	23.05
Options	0.74	6.00	0.12	1.67	2.30	12.06
Random factors	3.98	54.00	0.07	-	-	64.90

Note. *D is the sum of the squared deviations (deviant); s2 – the dispersion; n-1 is the number of degrees of freedom; h2x – force of influence on the effective attribute.*

It is established that the strength of the influence of factors on the effective feature "The value of the indicator of the total (total) productivity of aboveground and underground phytomass" varies in the series: random factors → repetitions (conditions of a separate field) → variants (species composition of the grass stand).

The results of the dispersion analysis of the total (total) productivity of aboveground and underground phytomass of perennial grasses using soil-saving technologies in comparison with traditional methods of tillage showed that the actual F is less than the theoretical F, which rejects the null hypothesis and indicates that the difference between the options is unreliable.

4. Conclusion

1. As a result of our comprehensive assessment of perennial grasses in the fallow area, in the system of soil conservation agriculture and with traditional technologies, it was found that the total aboveground and underground productivity of the studied crops of alfalfa, cereal-legume grass mixtures and fallow lands is at the same level and the options do not significantly differ from each other in the accumulation of absolutely dry mass of organic matter.
2. Alfalfa culture provides greater aboveground productivity in comparison with cereal-legume grass mixtures and fallow land.
3. Cereal-legume grass mixtures and fallow land are distinguished by the unity of the production process. In these plant communities, there is a significant accumulation of organic matter in the

underground sphere and a high ratio of aboveground and underground mass, exceeding those for alfalfa crops.
4. The fundamental difference between alfalfa crops and cereal-legume grass mixtures is that alfalfa crops accumulate a greater amount of organic matter in the aboveground part compared to cereal-legume grass mixtures and provide a much narrower ratio of underground and aboveground mass compared to grass mixtures.
5. Alfalfa crops, providing greater aboveground productivity, are more intensive in terms of production, but less effective means of increasing the content of organic matter in the soil compared to cereal-legume grass mixtures.
6. In soil conservation agriculture, it is necessary to use cereal-legume grass mixtures as more natural-like, and to increase the intensification of agricultural production – alfalfa crops.

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