The role of grassland crop rotation in piedmont zone of North Ossetia-Alania

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Abstract. The purpose of the study is to identify the effect of grassland crop rotation crops on the physical, agrobiological parameters of soils and on crop productivity in the forest-steppe zone of the Republic of North Ossetia-Alania. Tasks of the experiment: to study the structural and aggregate composition of the soil; to determine the volume mass of the soil under crop rotation crops; to identify the general biological activity of the soil; to identify the effect of crop rotation crops on productivity. The object of the study is the crops of the grassland crop rotation. The research was carried out in the field stationary crop rotation of the NCMPARI VSC RAS in the conditions of the forest-steppe zone of the RNO-A. The soil of the experimental site is represented by leached chernozems on pebbles, where humus ranges from 3.4 to 4.7%. The experiments were carried out in triplicate. The area of the experimental plots is 100 m² and registration plot is 96 m². It was found that at the beginning of the growing season, the lumpy fraction under crop rotation crops varied from 13.50% to 50.10%, and soil lumps from 0.25 to 10 mm (macrostructure) – from 49.40% to 82.60%, fraction <0.25 mm – from 1.80 to 8.0%. The index of the structural coefficient ranged from 2.22% (corn) to 2.49% (oats + clover). Studies have proven that leached chernozems contain from 45.0 to 66.5% of aggregates that resist the eroding effect of water, so these soils have a good structure. Over the years of research on oats + clover crops (on average 0–30 cm of soil layer), the soil density was 0.95 g/cm³ at the beginning of the growing season, 1.19 g/cm³ during the period of intensive growth, 1.22 g/cm³ at the end of the growing season. This tendency is evident in all crop rotation crops. In our studies, the best indicators for the collection of forage units were the grass links of the crop rotation and amounted to 15.05 t/ha. In the rowed link of the crop rotation they amounted to 13.12 t/ha. In general, the energy value of the grassland link of the crop rotation turned out to be 216.45 MJ more than the tilled one, and amounted to 255.0 MJ/ha.

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1 Introduction

Currently, in the Republic of North Ossetia-Alania, the steppe zone (Mozdok district) is mainly occupied by winter ear-forming and oilseed crops, and in the forest–steppe zone, corn and partially potatoes occupy the leading position. Corn in this zone has become a monoculture, i.e., it is sown annually on agricultural land, so it is not surprising that soil fertility has been severely depleted [1]. Therefore, the leading issue in the agriculture of the foothill zone is the proper crop alternation. In agronomy, crop rotations play a primary role among agrotechnical practices. Farming standards are increasing every year [1-3].

With proper crop alternation, yields increase annually. The scientifically based structure of acreage is the basis of crop rotations. In crop rotations, in which row crops alternate with continuous sowing crops, a decrease in nitrates is associated with the consumption of them by crops and the decomposition of their root system [4].

To a large extent, the agrophysical properties of the soil make up its fertility. The main indicator of soil condition is its bulk mass, which affects the agrophysical, chemical and biological parameters of the soil [5-6].

Low crop yields are greatly influenced by soil density, disruption of soil and atmospheric air metabolism, and oxygen balance in the soil, which makes it difficult for roots to breathe. With an increase in soil density, crop yields decrease due to a lack of oxygen in the soil and an excess of carbon dioxide, resulting in a decrease in soil activity [7-8].

The physical condition of the soil is determined by the fact that, with a favorable water-air regime, the development of microorganisms in the soil increases, which promotes the absorption of nutrients and improve nutrition conditions for plants [9-10].

In this regard, an urgent task in modern agricultural production is the development of effective, highly productive crop rotations.

2 Materials and methods

The research was carried out in 2020–2022 in the field stationary crop rotation of the NCMPARI VSC RAS in the conditions of the piedmont zone of North Ossetia-Alania. The soils under discussion are leached chernozem, underlain by pebbles. The mechanical composition in the upper horizons of these soils is heavy loamy, silty–clay. Leached chernozems have optimal physical properties, the specific gravity of humus is 2.49-2.53 g/cm3, they have a good water-resistant structure, pH – 5.1-5.7, gross forms of nitrogen in the soil – 0.25-0.45, phosphorus – 0.2-0.3, potassium – 1.6-2.3%. The sum of the average daily temperatures for the growing season is – 3200°C.

The scheme of the experiment:

- Oats + perennial grasses (green weight).
- Perennial grasses (green mass).
- Winter wheat.
- Potato.
- Corn.

The experiment is placed by a randomized method and carried out in triplicate. The total area of the plot is 100 m², and registration plot is 96 m².

During winter wheat growing seasons, one made records and observations. Plant and soil samples were selected according to the generally accepted methods set out in the educational and methodological manual written by Adinyaev E.D., Abaeva A.A., Adaeva N.L. [11]; "The methodology of field experiment" by Dospekhov B.A. [12].
3 Results and Discussion

We studied the effect of grassland crop rotation crops on the physical, agrobiological parameters of soils and on crop productivity in the forest-steppe zone. The main indicator of soil condition is its bulk mass, which affects the agrophysical, chemical and biological parameters of the soil.

Soil structure is the ability of soil to break down into soil aggregates of various sizes.

At the beginning of the growing season, the lumpy fraction under crop rotation crops varied from 13.50% to 50.10%, and soil lumps from 0.25 to 10 mm (macrostructure) – from 49.40% to 82.60%, fraction <0.25 mm – from 1.80 to 8.0%. For corn (at the beginning of the growing season), the share of the lumpy fraction was 49.45%, by the end of the growing season this indicator decreased to 23.91%; the same tendency was observed for potatoes. A different picture has developed between clover and winter wheat: at the beginning of the growing season, the lumpy fraction amounted to 15.21 and 13.35%, by the end of the growing season it increased by 23.98 and 28.58%. At the end of the growing season, the percentage of the dusty fraction under the winter wheat crop decreased from 7.96% to 1.05%, which was the lowest indicator. Among the crops: oats + clover and clover, this value amounted to 3.52 and 3.76% at the end of the growing season and 6.87 and 2.69% at the beginning of the growing season. In potato plantings, the share of this fraction decreased from 4.30% to 3.89%. The dusty fraction on corn crops increased from 1.77% to 5.60. The index of the structural coefficient ranged from 2.22% (corn) to 2.49% (oats + clover) (Figure 1).

Continuous sowing crops had a positive effect on the soil structure. Potatoes and corn (the rowed link), on the contrary, the structure of the soil. Studies have proven that leached chernozems contain from 45.0 to 66.5% of aggregates that resist the eroding effect of water, so these soils have a good structure. The soil density was different for the studied crops. The bulk mass increased by the end of the growing season. The average soil density between all crops was optimal throughout the study period. Over the years of research on oats + clover crops (on average 0–30 cm of soil layer), the soil density was 0.95 g/cm³ at the beginning of the growing season, 1.19 g/cm³ during the period of intensive growth, 1.22 g/cm³ at the end of the growing season. This tendency is evident in all crop rotation crops.

It was found that the proportion of the solid phase during the growing season increases when sowing winter wheat and corn, which is explained by a change in soil density. At the beginning of the growing season, general porosity is observed among crops: oats + clover (56.4%), clover (56.5%) and potatoes (57.7%), at the end of the growing season – clover (56.0%) and potatoes (58.5%). In clover crops, this indicator ranged from 41.3% to 41.4% in early spring and from 41.8% to 42.4% in the pre-harvest period. The level of capillary
Porosity among these crops ranged from 43.7% to 44.9%, at the beginning of the growing season – from 43.8% to 45.2%. It turned out that the capillary porosity increased from the beginning of spring to the middle of the growing season, because the root system of plants had already been formed by this period of development and one carried out inter-row tillage. Capillary porosity increased with depth, while non-capillary porosity, on the contrary, decreased. In general, the studied soil had an optimal phase ratio.

In our studies, the decomposition of cellulose was influenced by humidity, soil aeration and a complex of agrotechnical methods of cultivating crops (Figure 2).

![Figure 2](https://doi.org/10.1051/e3sconf/202449401016)

**Fig. 2.** The effect of crop rotation crops on the biological activity of the soil.

It is proved that the studied soil, according to the intensity of destruction of fiber, belongs to a weak cellulose decomposition scale. The highest rates of fiber destruction were observed for 90 days of exposure under potato plantings and amounted to 27.0%, under corn – 26.3%. Decomposition was less intense under clover crops of the second year of life – 20.2%.

For a more complete assessment of agrotechnical methods of cultivation of agricultural crops one can consider productivity and energy efficiency.

<table>
<thead>
<tr>
<th>Variation</th>
<th>Harvest, t/ha</th>
<th>Food units harvest, t/ha</th>
<th>EE, MJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Oats + clover</td>
<td>22.5</td>
<td>4.50</td>
<td>85.04</td>
</tr>
<tr>
<td>2. Perennial grasses (clover)</td>
<td>27.4</td>
<td>5.48</td>
<td>103.56</td>
</tr>
<tr>
<td>3. Winter cereals (winter wheat)</td>
<td>4.0</td>
<td>5.07</td>
<td>66.40</td>
</tr>
<tr>
<td>4. Potatoes</td>
<td>23.8</td>
<td>5.94</td>
<td>12.72</td>
</tr>
<tr>
<td>5. Corn for grain</td>
<td>6.3</td>
<td>7.18</td>
<td>25.83</td>
</tr>
</tbody>
</table>

The productivity of oats with clover was 22.5 t/ha, clover of the 2nd year of life – 27.4 t/ha, winter wheat grain yield – 4.0 t/ha, corn – 6.3 t/ha and potatoes – 23.8 t/ha.

It was found that in corn and potato crops, the yield of food units was higher and amounted to 7.18 and 5.94 t/ha, and in oat and clover crops, the harvest of food units was 4.28 t/ha, clover – 5.26 t/ha, winter wheat – 4.97 t/ha.

In our studies, the best indicators for the collection of forage units were the grass links of the crop rotation and amounted to 15.05 t/ha. In the rowed link of the crop rotation they amounted to 13.12 t/ha.
In terms of the energy potential of cultivated crops and the link of crop rotation, the grass field had an advantage. The highest energy values in the grassland link of the crop rotation were for oats + clover – 85,004 MJ, clover 2nd years of life – 103.56 MJ, and in the rowed link for corn for grain – 25.83 MJ. In general, the energy value of the grassland link of the crop rotation turned out to be 216.45 MJ more than the tilled one, and amounted to 255.0MJ/ha.

4 Conclusion

It was found that in the studied crop rotation, perennial grasses and winter wheat, since they have a more powerful root system, with a longer growing season, have a positive effect on the soil structure, and row crops (corn, potatoes) are noticeably inferior to them.

It was proved that at the beginning of the growing season, the lumpy fraction under crop rotation crops varied from 13.50% to 50.10%, and soil lumps from 0.25 to 10 mm (macrostructure) – from 49.40% to 82.60%, fraction <0.25 mm – from 1.80 to 8.0%. The index of the structural coefficient ranged from 2.22% (corn) to 2.49% (oats + clover). Studies have proven that leached chernozems contain from 45.0 to 66.5% of aggregates that resist the eroding effect of water, so these soils have a good structure. Over the years of research on oats + clover crops (on average 0–30 cm of soil layer), the soil density was 0.95 g/cm³ at the beginning of the growing season, 1.19 g/cm³ during the period of intensive growth, 1.22 g/cm³ at the end of the growing season. This tendency is evident in all crop rotation crops.

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References

5. L.V. Yushkevich, V.V. Chibis, Features of the formation of field crop rotations in the conditions of the forest-steppe of Western Siberia, Bulletin of KrasGAU, 9, 174, 35–43 (2021)
7. B.P. Boincan, Efficiency of crop rotations and permanent crops in the Republic of Moldova, Fertility, 1, 124, 32–38 (2022)

8. A.V. Kolmykov, Crop rotations as an organizational and territorial basis for increasing the efficiency of land use, Bulletin of the Belarusian State Agricultural Academy, 3, 116–121 (2010)


12. B.A. Dospekhov, The methodology of field experiment with the basics of statistical processing of research results ("Kniga po Trebovaniyu", Moscow, 2013)