Non-traditional legumes in the soil-protecting crop rotation of the mountain zone of the Republic of North Ossetia-Alania

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Abstract. Mountainous and sloping lands occupy one third of the territory of our country, more than 50% in the Republic of North Ossetia-Alania, and are a huge reserve for increasing agricultural production. Soil and climatic conditions on the slopes of the mountains and in the intermountain valleys make it possible to grow environmentally friendly products, to heal the seeds of agricultural crops from viral diseases. Increasing the production of agricultural products is one of the most important problems of agriculture. The mountainous territory of the Republic of North Ossetia-Alania is an important reserve for increasing the volume of agricultural production. About forty percent of the total area of the republic is concentrated here, most of which is characterized by favorable soil and climatic conditions. The development of agrotechnical, anti-erosion measures is one of the factors of preventing erosion processes in the soil and restoring soil fertility. The research was carried out in a mountainous area on mountain-meadow soils. According to the mechanical composition, it is middle loamy. The soil contains a high level of organic matter. It is moderately provided with hydrolyzable nitrogen and mobile phosphorus, and is highly provided with potassium. Studies have shown that these soils are favorable for the cultivation of perennial non-traditional leguminous grass species - eastern galega and crown vetch and the obtaining of products with high feed rates. The greatest soil protection effect from water erosion in the crop rotation was possessed by perennial leguminous grasses cultivated on a herbage – clover with timothy, eastern galega and crown vetch, which have a coefficient of soil protection from water erosion. In the soil-protecting six-field crop rotation eastern galega and crown vetch improved the structural and aggregate composition of the soil, the water resistance of soil aggregates, density and pore volume, also they increased soil fertility.

1. Introduction
One of the most important problems of agriculture is to increase the manufacture of agricultural products (grain, feed, vegetables, etc.) and improve its quality. In increasing the production of
complete feed in North Ossetia, an important reserve is the cultivation of non-traditional perennial leguminous plant species. Generally, erosion processes increase due to unsystematic and irrational effects on the soil in order to obtain the maximum amount of agricultural products, especially on the sloping lands of mountains and foothills. As a result one can see the following consequences: deterioration of physical, chemical, and biological properties of soil, reduction of its fertility, and environmental pollution of soil, water, and products [1,4].

One of the factors of prevention of erosion processes in the soil, restoration of soil fertility in crop rotations and cultivation of orphan land, stabilization and stability of the resulting products, is the development of agrotechnical, anti-erosion measures, including soil-protecting crop rotations with 2-3 fields of cultivation of perennial grasses.

To solve the set tasks, we studied the cultivation of non-traditional legume plant species with different life expectancy, productivity, ability to restore effective, rational soil fertility and to improve the phytosanitary condition of the fields in the mountains on the northern slopes with a steepness of 5 – 7° in the developed soil protection six-field crop rotation with 3 fields of perennial grasses [3,5].

In the mountain soil-protecting six-field crop rotation there was studied the following pattern of crop rotation:

1. Common oats + perennial grasses for green food;
2. Perennial grasses for 1 year;
3. Perennial grasses for 2 years;
4. Potatoes;
5. Autumn-sown rye for grain;
6. Common oats for grain.

From perennial grasses were cultivated the following legumes and cereals – clover with timothy, medic, and from the most valuable non-traditional types of grasses – eastern galega and crown vetch.

**Eastern galega (Jalega orientalis lam.)**

is a perennial legume herb, characterized by high productivity, early regrowth, drought resistance and high nutritional content of feed.

Due to the heavy root system and the presence of a large number of nodule bacteria, eastern galega, as well as other legumes, is a good nitrogen fixator, and when sown in a mixture with grasses, it has a positive effect on improving the structure, increasing soil fertility and its anti-erosion ability.

**Crown vetch (Coronilla Varia L)**

is a perennial legume with numerous elevated shoots, having ascending or branching stems with a height of 30 – 120 cm, and a root system in the form of vertical and horizontal roots [2,6,7].

By the autumn-winter period, additional large vegetative and generative shoots grow from underground buds, which then form a crop of herbage and seeds, leaving a large biomass that enriches the soil with organic matter, increasing the agrophysical and agrochemical properties of the soil and its anti-erosion resistance [8,9].

### 2. Results and discussion

An important indicator of the physical condition of the soil is its structure, which contributes to the formation of favorable water, air and nutrient regimes.

**Table 1.** The results of the research conducted in the soil-protecting crop rotation of mountain meadow soils on the influence of non-traditional leguminous grasses – eastern galega, crown vetch and other crop rotation cultures on the structural and aggregate composition of the soil.

| Culture                        | Lump size, mm | Pedality coefficient |
|--------------------------------|---------------|----------------------|
|                                | > 10          | 10 – 0.25            | < 0.25               |
| 1. Clover with timothy for 2 years | 17.0          | 80.2                 | 2.8                  | 3.4                   |
| 2. Eastern galega for 2 years | 17.5          | 79.5                 | 3.0                  | 3.2                   |
3. Crown vetch for 2 years  18.1  78.7  3.2  3.0
4. Autumn-sown rye for grain  20.8  74.4  4.8  2.9
5. Potato  24.4  71.9  3.7  2.5
6. Common oats for grain  21.5  73.4  5.1  2.7

Table 1. The above data show that by the end of the growing season, eastern galega and crown vetch, as well as clover with timothy, favorably affect the structural state of the soil, where the indicators of agronomically valuable soil aggregates (lumps – 10 – 0.25 mm in size), the silt fraction of the soil (< 0.25 mm) and the pedality coefficient were almost at the level with those of clover with timothy, since their well-developed root system improved the soil consistency and prevented it from the destructive effects of precipitation and meltwater.

The smallest number of agronomically valuable aggregates (10 – 0.25) were found in potato plantings – the pedality coefficient of soil was low (2.5). Under Autumn-sown and common oats for grain the structural and aggregate composition of the soil was the same, the pedality coefficient was 2.7 – 2.9.

Table 2. It was revealed that the studied alpine humus soil has a satisfactory structural condition, since it contains from 45 to 56 % of water-stable aggregates. In our experiments, perennial traditional, non-traditional leguminous herbs (Eastern galega, crown vetch) had different effects.

| Crop rotation cultures | Water stability, % | Density, g/cm³ | Pore volume, % |
|------------------------|--------------------|----------------|---------------|
| 1. Clover + timothy for 2 years | 51.4 | 1.12 | 57.7 |
| 2. Eastern galega for 2 years | 50.7 | 1.10 | 56.5 |
| 3. Crown vetch for 2 years | 49.8 | 1.13 | 55.7 |
| 4. Autumn-sown rye | 48.8 | 1.15 | 53.7 |
| 5. Potato | 46.6 | 0.91 | 60.0 |
| 6. Natural vegetation (layland) | 52.2 | 1.14 | 57.5 |

The indicators of water stability of soil aggregates under clover with timothy, eastern galega, crown vetch and layland were close to optimal values, they were slightly lower under autumn-sown rye and potatoes. The analysis showed that the best water stability of soil aggregates, the density and pore volume of the soil was noted at the beginning of the vegetation period, when the soil was not yet compacted by processing and not sprayed by heavy rainfall.

The pore volume of the soil is slightly higher under the clover and on the layland, however, there is no natural tendency to increase it in comparison with other crops. In connection with the cultivation of the soil on potatoes, the pore volume is quite high. There are no clearly defined deviations along the horizons, which should be explained not only by the influence of the root system of the cultivated crops, but also by the gravel content of the soil.

The duration of plant growth and the projective coverage of its soil surface determines the level of erosion processes in it.

The runoff in the process of its formation, moving along the ground, brings nutrients from the soil down the slope. The more intense and prolonged the precipitation, the more clearly the patterns of erosion processes are manifested. The stronger and longer the vegetation grows, the more it extinguishes the energy of precipitation and reduces soil erosion.

As a result of the conducted studies in the mountain soil-protecting crop rotation, it was revealed that the highest soil washout was for autumn fallow – 3725 kg/ha, and under potatoes – 2975 kg/ha, and the lowest for layland of 65 kg/ha and perennial legumes – clover, eastern galega and crown vetch 315 – 427 kg/ha.
The planting of perennial grasses under the cover of common oats also protected the soil from flushing.

The greatest soil protection effect is possessed by perennial leguminous grasses cultivated on the herbage – clover, eastern galega and crown vetch, where the coefficient of soil protection from erosion was 0.85 – 0.93. The indicators for soil flushing under autumn-sown rye are similar.

We established the direct dependence of the loss of nutrients on the amount of soil flushing. Thus, on potato plantings, the losses were: nitrogen – 55-60, phosphorus – 179 – 185, potassium-307-325 kg/ha, on autumn-sown rye they decreased by 3 times, and on perennial legumes and cereals of traditional and non-traditional grasses (eastern galega and crown vetch), the losses of nitrogen, phosphorus and potassium were the least.

The main mass of labile soil nutrients is accumulated in the upper root-inhabited plough-layer. On the sloping lands under the influence of water erosion there occurs the destruction of the upper most fertile humus layer. Therefore, the primary agricultural approach here is the preservation of the surface most fertile soil layer by a soil protection complex, which is based on crop rotation.

Table 3. The conducted studies have shown that in the soil-protecting six-field crop rotation the highest content of labile forms of nitrogen, phosphorus, exchangeable potassium and humus was observed on the crops of perennial leguminous grasses – clover with timothy for 2 years, leguminous non-traditional grasses – eastern galega, crown vetch and on the layland.

Table 3. The content of labile soil nutrients under the crops of the soilprotecting crop rotation in the 0-20 cm soil layer

| Crop rotation cultures | mg/kg abs. arid soil | Total nitrogen, % | Humus, % |
|------------------------|----------------------|------------------|----------|
|                        | P_2O_5 | K_2O |                  |          |
| 1. Clover + timothy for 2 years | 144.7 | 316.0 | 0.92 | 5.9 |
| 2. Eastern galega for 2 years | 139.5 | 297.0 | 0.93 | 5.8 |
| 3. Crown vetch for 2 years | 135.6 | 275.0 | 1.04 | 5.8 |
| 4. Autumn-sown rye | 133.6 | 266.7 | 0.82 | 5.5 |
| 5. Potato | 132.7 | 181.0 | 0.74 | 4.7 |
| 6. Layland (meadow) | 148.3 | 287.0 | 1.09 | 6.3 |

In the stocks of total nitrogen, labile phosphorus under the crops of clover, eastern galega, crown vetch and other cultures of crop rotation, there are no clear and regular differences in this soil.

However, there was observed that the content of nitrate nitrogen at the beginning of the growing season under perennial grasses, autumn-sown rye and on layland was less than ammonia nitrogen, due to the early initial growth rate and slow decomposition of organic matter. In the middle of the growing season, the nitrate content decreased from 12.4 to 0.5 mg/kg of soil. While the accumulation of ammonia nitrogen was quite high (14.7-19.6 mg/kg).

According to Professor G. G. Dzhanaev (1970) and K. Kh. Byasov (2001), the alpine humus soils of the subalpine belt are rich in reserves of exchangeable potassium (303 – 395 mg/kg). According to our data, under perennial grasses and on laylands, the K_2O content was in the range of 275-316 mg/kg of arid soil. Higher potassium yield was observed on potatoes due to the formation of the crop biomass, which reaches 270-300 hwt/ha.

Biological activity. The activity and direction of biological processes occurring in the soil depends on the rate of transformation of various compounds, the decomposition of plant residues, the accumulation of nutrients and, ultimately, the fertility of the soil and the productivity of field crops.

An important indicator of the biological activity of soils is the intensity of decomposition of plant residues (fiber). They are destroyed by specific microflora: bacteria, actinomycetes, microscopic fungi. Aerobic microorganisms play a particularly important role.

In the soil-protecting crop rotation in the 0-30 cm soil layer, the greatest activity of microflora was observed under perennial grasses (clover, eastern galega, crown vetch), where the percentage of
decomposition of linen reached 38 %, under autumn-sown rye – 25 %, potatoes –27 %. However, with a prolonged absence of precipitation, the rate of decomposition of linen significantly decreased.

3. Conclusions
1. The conducted studies have shown that the alpine humus soils at an altitude of 1450 m above sea level are favorable for the cultivation of the following perennial non-traditional leguminous grass species – eastern galega and crown vetch and for the manufacture of products with high feed rates.
2. The greatest soil protection effect from water erosion in the crop rotation was possessed by perennial leguminous grasses cultivated on a herbage – clover with timothy, eastern galega and crown vetch, in which the coefficient of soil protection from water erosion was 0.83 – 0.95.
3. In the soil-protecting six-field crop rotation eastern galega and crown vetch improved the structural aggregate composition of the soil, water stability of soil aggregates, density and pore volume of the soil, and increased soil fertility.

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