Productivity and nutritional value of natural forage lands on gullies and gullies

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Abstract. When creating environmentally sustainable agricultural landscapes, an important role is given to the rational use of the lands of the hydrographic fund, especially ravine-gully. These lands experience the greatest erosion load, since water flows from them from the entire catchment area through them. They are more affected by ravines and need reclamation not only from the standpoint of increasing land productivity, but also from the standpoint of protecting rivers and reservoirs from the products of flushing transported through these systems. In addition, the prevention of new ravine formation, the suspension of growth or the reclamation of ravines on these lands will save from the destruction of arable land on the slopes adjacent to the beam network. According to the agro-ecological state of the lands of the hydrographic fund, it is possible to judge the anti-erosion structure of the arable land and, in general, the agrolandscape. In the Central Black Earth Zone, due to the considerable plowing of the territory, the lands of the hydrographic fund are mainly occupied by natural fodder land, the yield of which does not exceed 40 kg / ha of green mass. More than half of the area of these lands is eroded, and about 120 thousand hectares are affected by ravines and practically excluded from agricultural use.

The main reason for the decline in the productivity of natural forage lands is their misuse. The high load of pastures, the lack of appropriate measures for the care of grass and turf lead to degradation of the vegetation cover. Grasses valuable in fodder terms fall out and low-value, weedy, noxious and poisonous plants are introduced, the grass stand is thinned out, the turf itself is destroyed. Pasture productivity is reduced by 3-4 times due to the fact that the landscape was not taken care of. An unproductive thinned grass stand weakly protects the soil from erosion, and as a result, the manifestation of which significantly reduces the fertility of the land and the productivity of the land. Studies have shown that the yield of natural grass on poorly washed dark gray forest soils and leached humus is reduced by 8–36% compared with unwashed, on medium-washed - by 39–62% and on highly washed-out - by 67–77%.

Improving and increasing the productivity of natural fodder land on erosive and eroded lands is not only one way to increase feed production, but also a means of protecting soils from erosion, protecting rivers and water bodies from siltation and pollution.

Gully-ravine systems, more than 80% of which are occupied by natural fodder land, are an element of a complex natural complex and are characterized by a wide variety of environmental conditions. This
is due to the diversity of the microrelief and soils, the different intensities of water flow, the microclimate conditions of the slope exposures, and other factors.

The southern slopes are better illuminated in comparison with the northern slopes, which affects the thermal regime of soils. According to our observations carried out on girder slopes with a steepness of up to 16°, the temperature of the surface layer of air on the slope of the southern exposure in July–August was 1.8–3.7 °C higher than on the northern one, and on sunny days the difference reached 13° FROM. This also contributed to an increase in soil temperature in the upper 0–5 cm layer by 3–6 °C compared with the exposure of the northern slope.

The steep girder slopes of opposite exposures differ significantly in the amount of precipitation arriving at them, the magnitude and intensity of the flow of spring melt water and soil erosion, we can see the degree of soil moisture. The collected research data, conducted in the experimental farm VNIIZiZPE [1,2,3], showed that more snow accumulates on the girder slopes of the northern exposure in winter and the largest flow of melt water forms here (table 1). On average, over 6 years, on the slope of the northern exposure, the water reserves in the snow were 30.5–33.8 mm, and the runoff was 19.6–25.0 mm more than on the slope of the southern exposure. As a result, a higher runoff coefficient is also observed on the slope of the northern exposure. The creation of a seeded grass stands by plowing and radical improvement of the lands on the beam slopes contributed to a 1.6–1.9 times decrease in the flow of meltwater, and the runoff coefficient was 0.22–0.30 versus 0.41–0.48 depending on the exposure on a natural grass stand.

The powerful turf of the natural grass stands of the medium-knocked pasture protected the soil from erosion, and no soil erosion was observed during the years of research. After the creation of the seeded grass stand, the soil was washed off only in the first year of grass life, and on average for 6 years its value was insignificant and amounted, depending on the exposure of the slope, to 0.14–1.13 t/ha. On the exposure of the southern slope, the soil is being washed away more rapidly and more than on the northern one, this is due to better illumination, more intense snowmelt and faster thawing of the upper soil layer (table 1).

Table 1. Meltwater runoff and soil washout on girder slopes with a steepness of 16° (average for 2010–2016, leached humus).

| Slope exposure | Water reserves (snow + precipitation) during runoff, mm | Meltwater flushing, mm | Drain coefficient | Flushing soil (turbidity), t/ha |
|----------------|--------------------------------------------------------|------------------------|-------------------|-------------------------------|
| **Natural grass** | | | | |
| North | 161.2 | 77.6 | 0.48 | 0 |
| South | 127.4 | 52.6 | 0.41 | 0 |
| **Seeded grass** | | | | |
| North | 159.0 | 47.8 | 0.30 | 0.14 |
| South | 128.5 | 28.2 | 0.22 | 1.13 |

Soil moisture varied significantly depending on the exposure of the slope. From the data of table 2 it can be seen that on average over 13 years, on the slope of the northern exposure, soil moisture in the 0–150 cm layer in spring, summer and autumn was 2.8–3.8% higher than in the south, 0–50 cm the difference in soil moisture over slope exposures reached 6%. Higher soil moisture on the slope of the northern exposure in spring is due to differences in snow reserves, and in summer and autumn, obviously, lower moisture consumption for evaporation in conditions of less intense light.

A variety of environmental conditions in ravine-girder systems determines the nature of the vegetation cover and productive land [4,5,6]. On fertile, well-moistened soils of the northern slopes, cereal-different-grass associations with good grazing-resistant turf prevail, and on more washed out and less moistened soils of the southern slopes, forbs-legumes-grasses with domination of forbs, which have a weak turf, are not stable enough to cattle grazing, and with intensive use, the productivity of these lands decreases sharply (table 2).
Table 2. Soil moisture in the 0–150 cm layer on girder slopes with steepness up to 16 °, % (average for 2010–2016, leached humus).

| Slope exposure | Natural grass | Seeded grass |
|----------------|---------------|--------------|
|                | Spring (April - May) | Summer (June - July) | Autumn (September - October) |
| North          | 26.8          | 23.0         | 25.2         |
| South          | 23.1          | 19.2         | 21.4         |

The path to improving meadows should begin with a more complete recognition of the nature of the grass stand as a plastic plant community, which means a transition to methods of improvement and use that are appropriate to the characteristics of the meadows and coming from the biology and ecology of meadow plants in a harmonious combination with the rational use of natural resources. A radical improvement, as noted by E. Klapp, in most cases is justified in those meadows where their initial state is worse. Plowing and reseeding should be carried out where superficial improvement is doomed to failure or only very soon success promises. In recent years, in Switzerland, Germany, New Zealand, considerable attention has been paid to the surface improvement of meadows, the preservation of part of the land in its natural state. Since they serve as a source of conservation of the gene pool of plants, a place for the reservation and reproduction of animals and birds, a means of protecting soil from erosion, zones for organizing health camps, modern agrolandscapes, or ecological clean zones with the maintenance of field and meadow lands. Compared to a radical improvement, surface improvement is more economical and environmentally friendly. In most of the natural forage lands of the Central Forest-Steppe, their productivity can be increased by surface improvement techniques, the implementation of necessary care measures and the proper use of grass stand.

A large amount of literature data and modern studies have shown [7,8,9,10] that when switching to a pen-and-batch system of cattle herding, the yield of natural pasture on steep girder slopes increases by 50–60%, and with annual fertilizing with mineral fertilizers, by 2.6–2.7 times. On average, over 7 years, depending on the exposure of the slope, with pasture use, the yield was 34–41 100kg/ha, and hay-pasture 43–48 100kg/ha of air-dry mass. The species composition of the grass stand has improved: the proportion of cereals in the crop has increased due to a decrease in forbs; there was no soil washout.

When creating a seeded grass stand by fundamentally improving the land without the use of fertilizers on unwashed and slightly washed leached humus, productivity increased by 1.5–1.6 times, and on medium and highly washed leached - by 2.0–2.3 times, that is, on unwashed and in poorly washed soils, a radical improvement ensured a yield increase at the same level as normal grazing. At the same time, on medium and heavily washed soils, the effect of a radical improvement was more significant.

Sown grass stands to a lesser extent than natural ones respond to rainfall during the growing season and give more stable yields over the years. So, on the slope of the southern exposure, the difference in the yield of natural grass stand in the years with wet and dry vegetation periods was 69–82%, and for the seeded - 22–28%, on the slope of the northern exposure, 20–21% and 9–13%, respectively.

Based on the foregoing, it follows that lands located on medium and highly washed soils of the southern slopes, that is, lands located on poorer soils, in more arid conditions, need radical improvement. Studies conducted by us at a multifactorial hospital, revealed the degree of influence of a number of factors on the yield of natural and seeded grass stands. The following factors were studied: weather conditions of the growing season, fertilizers, methods of using grass stand, and exposure of the slope. Fertilizers have the greatest effect on yield variation: in percentage terms, it is 47% for natural grass stand and 61% for seeded. Other factors by degree of influence can be ranked in this order: conditions of the growing year (31% of the total variation), method of use (12%), exposure of the slope (1%) for natural grass stand and method of use (26%), conditions of the growing year (5%) and the exposure of the slope (2%) of the general variation for the seeded grass stand.
The research results showed that when applying mineral fertilizers with the norm $N_{60}P_{60}K_{60}$, the yield of natural and seeded grass stands on average over the past 16 years increased 1.7–2.1 times (table 3). The highest yield increases were obtained on seeded grass, which, depending on the exposure of the slope, amounted to 24.3–27.6 100kg/ha of hay, against 18.6–21.5 100kg/ha on natural. It should be noted that fertilizers on a more humidified northern slope provided stable yields of natural grass stand for 16 years, while on the southern slope in the first 8 years the yield was 6.6 100kg/ha of hay less than in subsequent ones. This is due to humidification conditions during these periods, as well as a change in the composition of the grass stand on the southern slope under the influence of fertilizers. It has been established that on the northern slope, natural grass formation forms a higher yield in years with arid, and on the southern slope, on the contrary, in years with a humid vegetation period.

The radical improvement of natural fodder land contributes to a sharp increase in productivity in the first years of use of seeded grasses [11,12,13]. In the following, without the use of fertilizers, and the necessary measures for the care and use, the yield practically does not differ from the natural grass stand.

So, from the data of table 3 it is seen that in the first 8 years of use, the yield of seeded grass stand was 12.4–17.0 100kg/ha higher compared to natural grass stand, and in the next 8 years it was even lower. The yield dynamics over the years showed that already at the 5-6th year of using herbs, the yield of seeded grass stand did not exceed the natural yield. The use of mineral fertilizers contributed to the preservation of high productivity of seeded grass stand for 16 years, and it amounted to 56.5–56.8 100kg/ha of hay during the period with $N_{60}P_{60}K_{60}$ (table 3).

**Table 3.** Productivity of natural and seeded grass stands on steep girder slopes during haying use (100kg/ha of hay, medium leached humus).

| Fertilizer     | Northern slope exposure | South slope exposure |
|----------------|------------------------|---------------------|
|                | Average for 16 years   | Including average   | Average for 16 years   | Including average   |
|                | (2000-2016)            | for the first 8 years (2000-2008) | (2000-2016) | for the first 8 years (2000-2008) |
|                | including average over the next 8 years (2008-2016) | |
|                | South slope exposure   | including average   | South slope exposure   | Including average   |
|                | Average for 16 years   | for the first 8 years (2000-2016) | (2000-2016) | for the first 8 years (2000-2008) |
|                | including average over the next 8 years (2008-2016) | |
| Natural grass | 22.9                   | 27.9                | 17.8                  | 25.5                | 24.2                | 26.8                |
| $N_{60}P_{60}K_{60}$ | 47.4                   | 47.4                | 47.3                  | 44.1                | 40.8                | 47.4                |
| Seeded grass (radical improvement) | 29.2                   | 40.3                | 18.2                  | 32.2                | 41.2                | 23.1                |
| $N_{60}P_{60}K_{60}$ | 56.8                   | 61.2                | 52.4                  | 56.5                | 61.6                | 51.3                |

* Fertilizers were introduced from the second growing year of research.

It has been established that grazing using a herd-batch system of grazing cattle and fertilizers does not adversely affect the productivity of seeded grassland, and the creation of cultivated pastures on girder slopes provides a direct cost reduction of 30-60% compared with haying [14,15,16,17].

Fundamental improvement is one of the main ways to engage in agricultural circulation and increase the productivity of contaminated lands. The experience of developing gully-ravine lands for sowing hayfields in farms of the Kursk region, according to the developed guidelines and technologies for caring for gully-ravine lands, shows that with land occupied by ravines up to 20% and their depth up to 10 m, the return on investment does not exceed 10 years and secondary ravine formation is not observed. It is advisable to divert the lands with a greater degree of affliction and deeper ravines under afforestation.

To improve the productivity of natural forage lands not shot down and not affected by ravines, surface improvement is applied [18,19,20]. A significant effect was obtained when applying a set of techniques for surface improvement of natural pasture on the girder slopes of western and eastern exposition with a steepness of 9–11° in the experimental farm of the Institute of Agriculture. This set of techniques was aimed at regulating the flow of meltwater, improving the water-air and food regimes of the soil, improving the species composition of the grass stand and included flat cutting, partial destruction of the turf by discarding, sowing grass, sizing with a rotary sifter with sowing the wings from the lupine into the gap zone and introducing mineral fertilizers. When applying the above complex
of methods of surface improvement, the yield of the land increased from 25 to 82 100kg/ha of hay, the flow of meltwater decreased by 2.4–3.9 times, soil erosion decreased by 6–8 times, and the removal of nutrients by 2–8 times.

Consequently, the choice of land improvement methods must be approached differentially, taking into account the ecological characteristics of the land and the state of the vegetation cover. The priority role in increasing the productivity of natural fodder land on erosion-hazardous slope lands should be given to surface improvement, their rational use with the establishment of optimal load on pastures and regulated grazing. A radical improvement should be carried out on knocked-out areas, with a bad cultural and technical condition. The creation of seeded grass stands on washed away and contaminated lands is one of the main ways to increase the productivity of these lands, involving them in agricultural production, protecting soils from erosion, and preventing soil from being transported to rivers and water bodies. It is advisable to divert the lands, medium and heavily affected by ravines, under afforestation.

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