

Optimization of agro-ecosystem in the Baikalia forest -steppe zone on the basis of floodplain hayfields cultivation

Zoya V. Kozlova¹, and Vlada V. Kolocheva^{2,*}

¹Irkutsk Scientific Research Institute of Agriculture, Irkutsk, Russia

²Novosibirsk State Technical University, Novosibirsk, Russia

Abstract. The results of the research study for determination the influence of the agronomic and technological operations the development of the agricultural areas and preservation of surrounding territories that promotes to increasing productivity in the conditions of the sustainable region development are considered in the article. By conducting the research various methods of the haymaking sod processing combined with treatment of natural herbage with herbicides were used. The analysis of the received data was found out that combination the herbicidal treatment with disking the turf can be used by development of degraded hayfields areas with small plant tussocks. The authors proposed the ways to improve the herbage, calculated economic efficiency of the technologies being developed and given the phytocoenotic and agroeconomic proving the effectiveness.

1 Introduction

Nowadays to provide the sustainable development of the society is an urgent theme. These tasks are decided by many organisations in the various spheres. The sustainable development goal as protection and restoration of terrestrial ecosystems and promotion to its rational use, sustainable forestry, desertification control termination and reversal of the process of land degradation and termination of the biodiversity loss process [1] was denoted by UN that is of interest to us. Agricultural and forestry enterprises are functioning with the biologisation and ecologization of the applied technologies [2-4]. The results of this sector activity will determine the achievement of the set goal.

One of the perspective directions of enterprises functioning is growing feed on the floodplain grasslands and pastures, at the some areas and uprooted forest territories on the base of the small budget.

Development of this direction is an actual task which aimed to stabilization agro-ecosystems in the forest – steppe zone of Baikalia which characterized by unstable productivity of the natural haymaking is located in the floodplain of the river. This task is determined the research theme. The main reason of the low productivity of the cultivated

*Corresponding author: vladakolocheva@yandex.ru

areas is an insufficient research and analysis of productivity and efficiency of choosed technologies.

Floodplain grasslands and pastures are necessary for the growing green fodder. It covers more than 600 thousands hectares in the region conditions. The most part of these agriculture lands is degraded and its productivity decrease every year.

The reason of the low yield and unstable productivity of all hayfields and pastures is insufficient caring for these areas are uprooted by bumps, the presence of shrubs and trees and the spread of soil erosion.

Therefore, it is necessary to conduct a set of agrotechnical measures for recultivation and native hayfields and pastures for it further use and transfer to forage lands. Technologies of the accelerated development for pastures and hayfields were absence earlier in this region. The research of this technology implementation experience in other regions demonstrated the positive result: the productivity of the can reach 2,5-3,0 tons per hectare of the hay.

Data of the research organizations show that use of the surface soil improvement allow to increase the productivity of the native meadow in 2-3 times and use of the basic soil improvement increase the productivity in 4-5 times. Thus, one of the most significant goals is to intensify the grassland forage production to decide the problem of the feed [5].

However, the economic analysis of the recommendational technological measures for improvement pastures and hayfields showed that its practical realization attended with huge labour and material and financial costs [6, 7].

At present the problem of agrotechnical techniques development to increase the fertility of meadows for further use is very important.

To construct protective forest belts and protection of the plantings is a necessary condition to use floodplain lands properly. Though, the complex study of this problem in the regional conditions has not conducted.

The main goal of the research is to elaborate the recommendations for accelerated surface and basic floodplain grasslands improvement are increasing to agro-economic system stabilization in the forest-steppe zone of Baikalia on the basis of the technological methods analysis.

Research tasks:

1. Study the effectiveness of methods to increase the productivity of floodplain hayfields by improving the species composition of the natural herbage by sowing a mixture of perennial grasses (*Bromus inermis* and *Trifolium pratense*) with seeders that use for sowing in hayfield turf without preliminary tillage.

2. Evaluate the effectiveness of floodplain hayfields surface treatment with disk implements to establish the replacement of plowing as the most energy-intensive technological method that use in the radical improvement of natural fodder lands.

3. Establish the methods of accelerated grassing of floodplain hayfields near the coniferous type of vegetation by improving the grass stand without the use of a herbicide and change the grass stand.

4. Identify the increase of the productivity level of improved floodplain hayfields due to various technological methods: sowing of perennial grasses, directly into natural untreated sod ("direct" sowing), methods of sod treatment and the applied herbicide.

5. Calculate the economic efficiency of the developed technologies.

Scientific novelty of research – for the first time in Irkutsk Region the complex of technological methods for the accelerated improvement of natural fodder lands – floodplain hayfields was studied; phytocenotic, fodder, agronomic and economic substantiation of its effectiveness is given. That technological complex might be used in the areas development, as we cultivate degraded hayfields, pastures and forest plantations and protective forest belts.

2 Materials and Methods

The research was conducted from 2017 till 2022 years at the periodically filled (3-5 days) floodplain Ushakovka River (the right tributary of the Angara). In research years the floodplain has not filled. Experimental plot is located at 5 km from Pivovariha near the coniferous woodlands. Natural herbage of the floodplain grasslands consists of the cereal grasses such as bromus, bluegrass, fescue etc. – 30,6%, motley grass – 65,0% and sedges – 4,4%. [8]

The soil of the experimental plot is alluvial and sod with close occurrence of the gravel. The ground water depth level is 40-100 cm [8]. These soils has good fertility level. The process of soil formation and floodplain soil cover formation occurs due to alluvium.

The size of the one experimental plot is 300 square metr. It has a four-fold repetition.

The air conditions during the experience period are corresponded to average long-term data.

Field work research and observations were conducted due to common methods [9, 10].

The field research method requires:

- to study the system herbicide of continuous action «Hurricane-Forte»;
- to define the efficiency of the accelerated tinning without herbicide usage.

This experience includes five versions without herbicide usage that are presented in the table 1.

The experience scheme of accelerated tinning with previous herbicide entering has included five experience variants. Every experience has included herbicide «Hurricane-Forte» with 6 kilogram per hectare per 200 litres of water in the rate. Natural herbage by the time of the herbicide addition was 15-17 cm in height. Three weeks later, when natural herbage completely died, we made the next experiment technological operations. The first version of the experiment (version 2b), without pre-sowing tillage, has included the addition of the mineral fertilisers and then direct seeding perennial herbs mix by domestic seeder MPS-16. The second version of the experiment (version 3b), without pre-sowing tillage, has included the entering the basic norm of the mineral fertilisers and making the seeding perennial herbs mix by seeder of direct seed Vredo 125075. The third version of the experiment has included disking by two times, addition the fertilisers and seeding by MPS-16 after the herbage died. The version (5a) has included next operations: plowing and disking, basic fertilisers addition and seeding perennial herbs mix. The version (6a) has included: disking, plowing with disking, addition the fertilisers and seeding the experienced grass mixture [8].

Every two years at the experimental plots was conducted the re-sowing of the meadow clover. The natural herbage of the floodplain grasslands was stated as a control in this experiment. At present the research are conducting.

Table 1. Characteristics of soil cultivation variants.

Variants	Cultivation	Equipment
2a	Direct sowing of mix perennial grass. Withouttreatment + fertilization N45P30K30	Seding rate Bromusinermis 12 kilogram per hectare, Trifoliumpratense 8 kilogram per hectare, sower MTS-16
3a	without sod treatment and sowing the mixture of perennial grass	sower Vredo 125075 Dutch production for sowing herbs without soil mechanical processing
4a	With double disking of turf meadows, application of fertilizers and following sowing a mixture of perennial herbs	sower MTS-16; plowing + following disking of soil, application of fertilizers and following sowing a mixture of perennial herbs
5a	disking + plowing + disking, fertilizer application and sowing of perennial herbs	Plow, diskheader

3 Results

This experiment showed that before the experience the natural herbage composition has a small quantity of the bluegrass and sedge plants on this plot. After the implementation of the agrotechnological methods the whole herbage was modified.

According to specialists' calculations the yield increase of valuable forage crops is growing approximately at 20-53 kilogram by every kilogram of added nitrogen fertilizer. The addition of the complex fertilizers improve the growth of leguminous crop and its mix by 25%.

The versions of the experience without herbicide at the fourth year by the direct seeding of the bromus and clover non - seeded plants grass haymaking the bluegrass family – 26,8%, motley grass – 9,9%, meadow clover – 13,3%, awnless rump – 17%, sedge – 3% [8]. The version of the double disking: the bluegrass family – 25%, motley grass – 4,9%, meadow clover – 32%, awnless rump – 20,1%, sedge – 2%. The next version: plowing and diskin, obscure cereals and motley grass, thereafter, 22,8% and 10,6%, clover – 35% and awnless rump – 31,6%; disking + plowing + disking of the obscure cereals – 12,7% and 6,4 % – motley grass, 41,9 % awnless rump and 39% clover [8].

The usage of the herbicide «Hurricane-Forte» was included in the experience versions. This is the systematic herbicide that has not a negative influence the soil composition and that is its main advantage. The direct seeding in these versions by seeder MPS-16 without pre-sowing tillage shows that productive mass of the bluegrass plants and meadow clover has increased by 1,5 times but motley grass has decrease.

Direct seeding by seeder Vredo 125075 has increased the productive mass of the bluegrass plants, clover and motley grass [8]. The growth of the specific weight of the bluegrassplants is provided by centralized seeding on all spades with seeder MPS-16.

The advantages of the seeder Vredo 125075 are that it designed for restoration of pastures and its implementation let us exclude the additional plow processing.

The experience versions with a pre-sowing tillage (version – double disking) have 49% bluegrass family, clover – 35%, motley grass – 16%, by plowing processing – 52,36 and 12 percentage appropriately.

The key factor for a well-executed herbage formation of sown perennial grasses is soil moisture content. It depended on the methods of preparation of the soil for tinning and treatment of natural herbage with herbicides. We marked low field germination of perennial grass seeds in the experience versions where we did not use the herbicide (field germination of awnless rump seeds was 30-31% and meadow clover 62-63%). Field germination of perennial grass seeds in the experience versions by seeding it's in the sod was cultivated by herbicide grew by 49% for awnless rump and 78% by clover. In the other experience versions the field germination of perennial grass seeds was fluctuated: awnless rump – 33-38%, meadow clover – 79-84%. In our opinion, the decrease of the field germination and the density of the herbage of perennial grasses depended on the difficult interspecific competitive relations that were developing in the designed meadow agrophytocenosis.

The measurements of perennial grasses and its density allow to conclude that in the experiment with the use of the herbicide «Hurricane-Forte», the density of the herbage was maximum – up to 900 pieces per square meter, and without it was half less – 484 pieces per square meter. The highest herbage density was observed in the experiment by using the Vredo 125075 seeder – 994 pieces per square meter.

The use of the continuous herbicide influence the plants density and its growth and height. Before the start of harvesting, plants measurements were carried out and was noted that the height of meadow clover was 101-105 cm, awnless rump – 137-140 cm. The height awnless rump was 124-127 cm and meadow clover – 95-96 cm.

Most part of the perennial leguminous crop tends to fall out of the herbage in the third and fourth years. Meadow clover should not be used by fourth year. However, in our field experiment, meadow clover used in the third year that led to its fall out from the herbage and a decrease of the feed. Thus, we made the re-sowing of the meadow clover.

Various methods of pre-sowing tillage with partial replacement of natural herbage with perennial grasses, in particular, awnless rump and meadow clover, that used in experiments (double disking) increased the productivity of haymaking by 3,5 times. It concerns the version where the agricultural technique of plowing was used before sowing the grass mixture and disking by 4,1 times and in the version with disking, plowing and disking by 4,4 times.

Experiment versions with sowing a mixture of perennial grasses with the preliminary addition of the «Hurricane-Forte» herbicide were more effective than without herbicide. Direct sowing with the SNP-16 seeder of bean-cereal mixture the productivity of haymaking increased by 2,5 times and sowing with the Vredo 125075 seeder by 4,5 times. In the experience version with mechanical tillage that was used before sowing grasses, the productivity of the improved hayfield increased by 4,3-5 times. The agronomic efficiency of the herbicides usage in the technological scheme for the accelerated improvement of floodplain haymaking was showed the increase in fodder units per hectare from 0,16 to 1,13 tons.

The results of the economic efficiency of the accelerated tinning of the floodplain grasslands methods are demonstrated that direct sowing the grass mixture in the turf by Vredo without herbicide had following parametrs: the cost of the one centner of fodder units was 164,8 rubles, profitability was 142,7%. The cost of the one center of fodder units was increasing as the number of the meadow sod treatments was growing.

4 Discussion

To sum up the results of the conducted research we need to underline the following points:

1. The analysis of the floodplain hayfields condition of the Baikalia indicates its deep, increasing degradation, depletion of the herbage species composition and low productivity. Therefore, it requires to diversify the composition by new forage crops and mixed grass crops.

2. An improvement of the species composition and its quality might be achieved as a result of sowing a bean-grass grass mixture: awnless brome and red clover – as with «direct» sowing in a natural grass stand of a hayfield and after pre-treatment of the sod. Use of «direct» sowing by higher agronomic efficiency was obtained by use of Dutch-made seeders – Vredo 125075 and various sod treatment methods by disking, plowing and re-disking.

3. It is better to use high quality seeds for the recovery of the unused for a long time pasture areas. It requires to scarification of seeds and previously planting seeds germination till carry out sowing (10-15 days before sowing).

4. The calculations showed that the greatest economic benefit was obtained by use the pre-treatment of natural herbage with the herbicide «Hurricane-Forte» in technology of accelerated grassing of floodplain hayfields. Fertilization is a high-speed reception for the improving soil quality.

Herbage yield by the direct sowing reached 3,8 ton per hectare by unit, the cost price 1 center by unit was 140,8 rubles and profitability was 184%. Fuel consumption in comparison to all technologies less than 2,6-5 times.

This tinning technology provided the reception of the most low-cost feeds.

Implementation of the research results in practice will allow to:

- provide, in comparison with the achieved level, higher productivity of agricultural crops and the quality of crop products;
- eliminate soil toxicity based on the use of biologization of red clover in fodder crop rotations;
- reduce and restore the rate of soil degradation by the use of green manure practices for perennial legumes.

Thus, the problem of the agrotechnical methods development is aimed to increase the fertility of meadows for further usage is urgent at present.

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