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Effect of Different Methods of Sod Layer Improvement on Phytocenosis of Southern Chernozems in the Steppe Zone of Akmolinsk Region

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This article submits results of a study of degraded grasslands improvement. During the study when herbage mixtures hadn't been seeded, the first treatment of a sod layer of low-yeilding degraded grassland plots with disk tillers provided the increase of herbage up to 1.0 tons/ha and of hay up to 0.3 tons/ha. In comparison with the control sample direct seeding of herbage mixtures in the sod layer allows improvement of the yield of herbage from 1.3 up to 9.5 tons/ha and of hay from 0.9 to 2.4 tons/ha.The maximum yield increase has been obtained by seeding herbage mixtures after the first treatment of the sod layer: yield of herbage has increased from 3.5 up to 10.9 tons/ha and yield of hay – from 0.7 up to 2.8 tons/ha. In comparison with the control sample, the two-component legume-grass mixture of medic and awnless brome has given the maximum yield increase among the studied components of certain herbage mixtures.

Key words: hayfields, grasslands, simplificat5d improvements, permanent grass, complex and simple herbage mixtures.

Natural forage lands covers 53 million ha in the northern dry steppe zone of Kazakhstan, including 7112.6 thousand ha in Akmolinsk region, with 6843.8 thousand ha of grasslands. Enbekshildersky region, where the experimental research are carried out, possesses 628.8 thousand ha of agricultural lands, including 357.1 thousand ha of grasslands[1].

Over the last 20 years excessive cattle grazing has led to deterioration of the species composition of grass stand and decrease of the yield. All the grasslands, including artificial and those which have undergone improvement 20-25 years ago, are of poor productivity and are subject to improvement and rational use[2].

With this regard development of climatic scheme of improvement and rational use of the natural forage lands (hayfields and grasslands) which takes into account local soil, environment and economical conditions, is a timely and prospective approach to agricultural studies, considering the demands of local agricultural and livestock-breeding enterprises.

For the purposes of livestock-breeding relying on natural forage resources, phytomelioration serves to creating artificial grasslands noted for higher and more stable yield compared to natural ones and providing animals

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with various forage all the year round. In the course of experiments aimed at improving forest-steppe and steppe hayfields and grasslands of northern Kazakhstan various artificial phytocenosis are created and tested. According to Momotov, I.F., Faziev, K., Sagalbekov, U.M., Koshen, B.M.[3], the term "phytoameliorants" refers to "artificial phytocenosis", or "artificial grasslands"[4-9], and "grasslands and haylands"[10-13], which are widely used in botanic literature and in grassland handling practice. To our opinion, in this case the term "agrophytocenosis" commonly used in science is the most appropriate one.

In many countries grasslands and hayfields are of key importance for feed balance of livestock breeding. For instance, in USA with regard to the nutritional value pasture forage amounts to 36.9% of all the forage given to all kinds of livestock, in beef livestock breeding this figure is equal to 53 %; breeding and growing stock takes up to 70 %, and mast-fed livestock just 5-6 %. In livestock breeding, in particular beef livestock breeding, of this country livestock feeding is intensified. Besides a share of pasture forage is increased together with the amount of concentrated feedstuff. With this regard, all the efforts have been aimed at grasslands improvement and shift to a rational system of feeding with the use of enclosure, fencing and gathering homogeneous sex-age groups of livestock[14].

As for European countries, in France grasslands and haylands, including permanent and artificial ones, cover 49 % of agricultural lands, in Great Britain 73%, in the Netherlands 59, in Belgium 49, in Germany 40 and in Denmark 21 % [15]. In Russia natural grasslands and haylands cover about 80 million ha, at this grasslands take in 76 % and haylands 24 %[16].

Today in the Republic of Kazakhstan the square of grasslands is equal up to 187.5 million ha, including 59.5 million ha of flooded grasslands. At this piedmont plane degraded grasslands cover 3.8 million ha, desert grasslands 13.2 million ha and forest-steppe and steppe grasslands 5.6 million[17, 18].

Analysis of existing materials has shown that grasslands located in different climatic zones are the main source of cheap and biologically nutritious forage for the summer period, while the cost of an energy unit produced by herbage (hay) is equal to as little as 1/3 of the cost of an energy unit produced of corn or 1/2 in haylage[19].

Over the recent years in the Republic of Kazakhstan the yield of grasslands has drastically decreased due to sparse herbage stand and poaching by livestock. As a result, they sink in the scale and balance between a grassland and an animal, where the environment provides self-renewal and self-regulation, is changed. In the herbage stands a share of the most valuable and yielding species of herbs has reduced. Hence, relying on their rational use there is the urgent need for recovering the lost natural herbage and its enrichment with legume-grass species in order to raise the yield by amelioration and simplificated improvement, acquire eco-friendly herbal forage and further preserving valuable species in the grasslands stand[20].

Materials and Methodology

The experimental study was carried out by means of field and laboratory experiments at a permanent study area located at the plots of natural forage land "Baymyrza-Agro", TOO, in Enbekshildersky area of Akmolinsk region.

A field experiment was prepared according to the procedure of the Russian National Institute of Forage n.a. Wiliams, V.R (VIK) and in accordance with a scheme shown in Table 1 which should be repeated over time.

In the course of the experiment the main methods of simplificated improvement, including its variant without sod layer treatment and with its treatment with disk tillers BDT-10, were studied: efficiency of resource-saving methods were assessed. All the concomitant observations were effected according to the Procedure of official crop variety testing of agricultural crops and the Procedure of research works at grasslands and haylands[21, 22].

The following species of permanent grasses have been used for seeding the herbage mixtures: fairway crested grass Batyr, awnless brome Lymanny, medic Shortandinskaya 2, Hungarian sainfoin Shortandisky 83. According to the certificate, the seeding usability of hayseeds was as follows: for fairway crested grass, the purity was 96.88%, the laboratory germination – 67.6%, the viability 52%; for awnless brome the purity was 99.40%, the laboratory germination 81.6%, the viability 62%; for medic the purity was 99.75%, the

laboratory germination 71.7%, the viability 67.3%; for Hungarian sainfoin the purity was 100%, the laboratory germination 82.7%, the viability 60%.

The herbage mixtures were seeded with a seeding machine SZS-2.1 with specially mounted cultivator points according to the seeding rates established by of the Russian National Institute of Forage researches of soil and climate conditions and by experiment data of scientific and research institutes and experiment stations dealing with calculation of rates of seeds and herbage mixtures. Hayseeds were seeded at a seeding rate of 4 million of germinable seeds. For the herbage mixtures consisting of two species of one biological group the seeding rate was cut by two and was equal to 50% of the seeding rate of not mixed seeds. Hayseeds were seeded at a depth of 2-3 cm.

RESULTS AND DISCUSSION

The experimental grassland plot is located in the dry steppe zone of Akmolinsk region with the severely continental climate. The highest attainable temperature falls within the summer months (June, July and August) and varies from 16° to 22° above zero, while the lowest temperature is observed in winter (December, January and February). The mean daily temperature rises above the zero in the first ten days of April, the warm period lasts from 75 to 90 days. The most of the rainfall is observed in autumn and in spring. The seasonal snow cover holds within 5 months, its mean thickness amounts to 20-35 cm. In the most years strong winds blow off the snow from fields. The snow starts melting in the first ten days of April. Since in spring the rainfall is insufficient, the main source of soil moistening is snowmelt waters. The first frosts occur in late August and the last spring frosts are observed in late May.

Soil cover of the grasslands mostly consists of chenozems, southern non-alkalinized, weakly alkalinized and alkalinized, minor and medium soils with medium and heavy loam texture. Agrochemical survey of soils from the grasslands plots was analyzed in a special agrochemical laboratory "AgroComplexExpert" in Zhaksy settlement in Zhaksynsky area of Akmolinsk region. The key fertility figures of the experimental plots with regard to soil layers are shown in Table 2.

Results of measurements of humus contents using Turin method (%), of labile phosphorus using Machigin method (mg/kg), of nitrate nitrogen using ionometric method according to Sdobnikova, O.V., (mg/kg) prove that the soil cover of natural forage lands at the studied grasslands has low content of these substances, while with regard to exchange potassium (measured by the Machigin method (mg/kg)) it is belongs to

Table 1. The scheme of the experiment

Variants of the experiment		
S. No	A way of sod layer treatment	A Herbage Mixture Composition
1	Without treatment (a control sample)	Without seeding
2	Treatment of the sod layer with BDT-10	Without seeding
3	Without treatment	fairway crested grass +brome+medic fairway crested grass +brome medic+brome sainfoin + fairway crested grass
4	Treatment of the sod layer	fairway crested grass +brome+medic fairway crested grass +brome medic+brome sainfoin + fairway crested grass

Table 2. Content of humus and soil nutritional chemicals, pH (average for the period 2012-2014)

A layer, cm	Humus, %	$N\text{-}NO_{3,}$ mg/kg	$P_2O_{5,}$ mg/kg	K_2O,mg/kg	pH
0-20	3.1	7.37	1.68	530.60	7.30
20-40		3.93	2.18	396.50	7.95

higher or high group. Acidity varies from neutral to medium-alkalinized.

In the years of the study the mean daily winter temperature (January, February) was lower by 2.6°C as compared to the mean annual figures and spring and summer temperature by 2-4 ^{0}!.

During the vegetation period the rainfall was rather irregular. In the course of the study in 2012 in the winter months (January and February) the rainfall was by 2,5-3 times lower than the mean annual figures and in 2013-2014 on the contrary it was by 2,5-3 higher (Table 4). In spring months the rainfall was equal to the mean annual rainfall. The average rainfall for three years amounted to 31.3 mm in June and 65.3 mm in July which was by 13.3 mm higher than the mean annual rainfall. In the summer months the rainfall surpassed the mean annual rainfall by 1.5 times, excluding the dry year of 2012.

During the period of the study at the experimental plot the average depth of snow cover was equal to 15.6 cm in January and 17.5 cm in February. Before spring aftergrowing and herbage mixture seeding efficient moisture resources amounts to 98.1 mm, reducing to 102.6 mm by the mid-June70 due to its intensive use by permanent grasses during the tillering and blooming period, and increasing up to 147.6 mm by the mid-July

Table 3. Field germination of the seeds and the number of permanent grasses in the herbage mixtures of the first year (the average for the period of 2012-2014)

Types of herbage mixtures	The number of germinable seeds, with regard to the seeding usability equal to 91%, plants/m^2		The total number of plants at the stage of fully germinated seeds, plants/m^2								Field germination, %	
	total	In particular, for each crop	total	for each crop	total	for each crop	total	for each crop	total	for each crop	total	for each crop
A plot of the natural grassland with direct seeding of the herbage mixtures												
	2012-2014		2012		2013		2014		mean		mean	
fairway crested grass + awnless brome + medic	400	100 100 200	124	39 35 50	268	40 72 156	295	54 68 173	228	44 58 126	57	44 58 63
Awnless brome + Fairway crested grass	400	200 200	114	66 48	120	64 56	227	132 95	153	87 66	38	44 33
Medic + Awnless brome sainfoin+ fairway crested grass	400	200 200 200 200	56 91	35 21 66 25	283 133	176 107 76 57	294 265	178 116 158 107	193 163	130 63 100 63	48 41	65 32 50 32
A plot of the natural grassland after treatment by BDT-10 and seeding the herbage mixtures												
fairway crested grass + awnless brome + medic	400	100 100 200	137	36 38 63	294	43 95 156	366	80 92 194	266	53 75 138	67	53 75 69
Awnless brome + Fairway crested grass	400	200 200	201	128 73	205	124 78	285	163 122	229	138 91	57	69 46
Medic + Awnless brome sainfoin+ fairway crested grass	400	200 200 200 200	122 169	86 36 42 127	350 156	174 176 92 64	362 309	189 173 176 133	278 211	150 128 103 108	70 53	75 64 52 54

after mowing and grazing and due to heavy rainfall.

Thus, analysis of the weather conditions in the course of the study has shown that only one year (2012) of the three can be described as excessively dry (hydrothermal index – 0,5), while 2013 and 2014 were rather productive and characterized as slightly dry (1,0-1,1). The prevailing moisture conditions of the dry year of 2012 negatively affected the herbage yield of the control variant and the variant with the primary treatment of a sod layer without seeding permanent grasses and the field germination of the permanent grass seeds of the variant with herbage mixtures seeding.

In the first year the optimum permanent stand thickness mostly depends on the proper choice of the seeding time and the moisture content at a primary stage of growth and development which allows attaining high field germination of the seeds and viability of the plants . In the course of the study seeds of the permanent grass included in the herbage mixtures were seeded in the first ten days of May. During the period of the study the stage of fully germinated seeds fell, in average, on the 25-30 day after germination.

For three years the average field germination of the seeds varied from 38 up to 67 % depending on prevailing weather conditions and the experiment variant.

For three years it was observed that the two-component herbage mixture (medic and awnless brome with prevailing medic) had the average high rate of field germination equal to 143 plants/m^2. The herbage mixture of fairway crested grass and awnless brome had the lowest field germinations which varied from 38% to 57%. For three years the average viability of plants was equal to 92.0-99/2% for all the experiment variants and all the types of the herbage mixtures.

Thus, for the three years of the study under the prevailing weather conditions the field germination of permanent grass and legumes varied from 38 to 67% during the first year after seeding the two- and three-component legume-grass and legume herbage mixtures. In the course of the study the legume-grass two-component mixture of medic and awnless brome showed the highest field germination. By the beginning of mowing maturity percentage of preserved plants of different types of the herbage mixtures varied from 92.0 to 99.2%.

On the second year after seeding the herbage mixtures and overwintering the permanent grasses from different types of the herbage mixtures preserved from 78.5 to 85.5% of plants on the average for two years (2013, 2014) of the study.

The highest rate of overwintered plants was observed in the two-component grass herbage mixture of awnless brome and fairway crested grass.

By the beginning of mowing maturity different herbage mixtures preserved from 48.7 to 98.9% of plants.

The number of stalks at one plant varied from 10 to 16 for medic, from 14 to 19 for sainfoin, and in the legume mixture of fairway crested grass and awnless brome one plant had from 5 to 11 stalks.

In total, on the average for two years of the study on the square unit there was from 821 to

Table 4. Economic efficiency of the components of saving methods of natural forage lands improvement, on the average for 2013-14 and 2014

Variants	Hay yield, tons/ha	The price of hay, tenge/ton	Total costs, tenge/ton	Operating profit, tenge/ton	Profitability, %
The permanent grasses of the third year (seeded in 2012)					
A plot without treatment and seeding (the control variant)	0.8	8000	1962	4438	100
A plot with sod layer treatment by BDT-10 and without seeding	1.1	8000	3888	4912	126
A plot with direct seeding of herbage mixtures	2.0	15600	10301	20899	203
A plot with sod layer treatment by BDT and direct seeding of herbage mixtures	2.5	19200	12227	35773	292

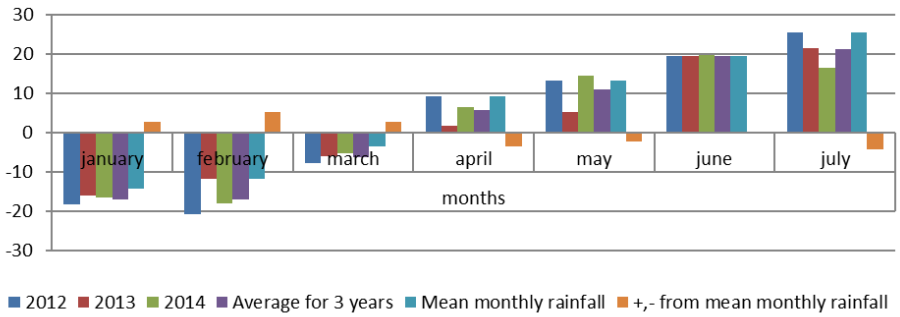

Fig. 1. Mean daily temperature for the period 2012-2014 as compared to the mean annual temperature, °C

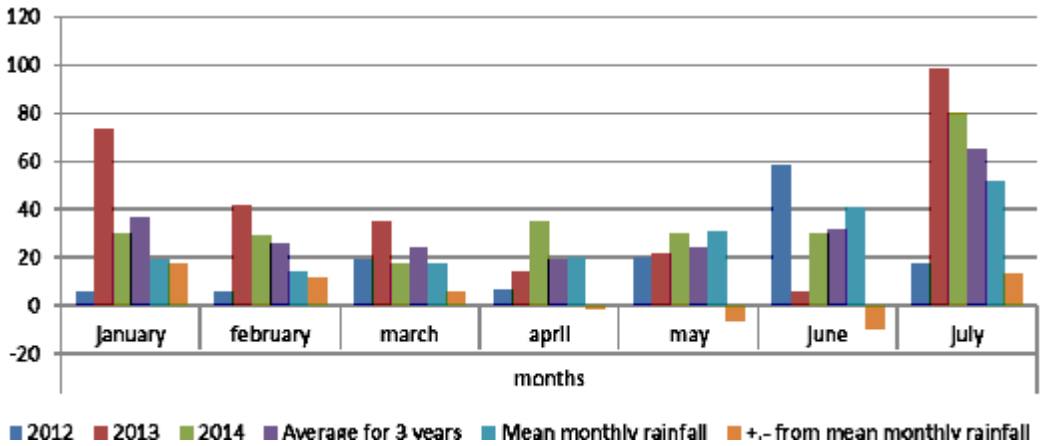

Fig. 2. The rainfall for the period of 2012-2014, as compared to the mean annual rainfall, mm

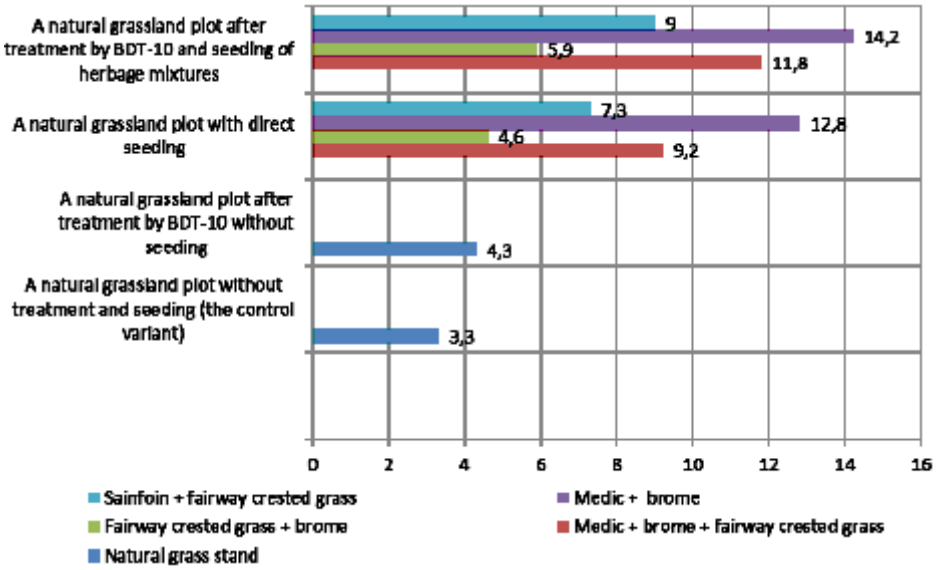

Fig. 3. Yielding of natural grasslands and permanent herbage mixtures of the second year (seeded in 2012-2013) depending on sod layer treatment, tons/ha (on the average for two years)

2702 stalks depending on the experiment variant; at this, the maximum of the stalks were observed in the herbage mixtures of medic and awnless brome, and the minimum in the legume herbage mixture of awnless brome and fairway crested grass without sod layer treatment. On the second year the permanent grasses attained the stage of mowing maturity over 56-58 days after accumulating effective heat sum from 712 to 778^0!.

On the plot of the natural grassland (the control variant) the height of the grass on the average for two years was equal to 20.1 cm depending on the prevailing weather conditions and on the plot after the primary treatment of a sod layer the grass was higher by 2.6 cm.

Depending on the applied agrotechnical methods the permanent grasses in the different herbage mixtures and the different experiment variants produced from 4.6 to 14.2 tons/ha of herbage, from 1.1 to 3.6 tons/ha of hay with as much as 0.6-1.8 tons of fodder units per a square unit. In comparison to the control variant (a plot of the natural grassland), it is by 1.3-10.9 tons more for herbage, by 0.3-2.8 tons for hay and by 0.2-1.4 tons for fodder units.

Among the studied herbage mixtures in all the experiment variants the highest yield was observed in the legume-grass two-component mixture of medic and awnless brome and the lowest in the legume herbage mixture of fairway crested grass and awnless brome. Depending on sod layer treatment the increase of herbage yield amounted to 5.9-8.5 tons/ha for the three-component legume-grass mixture of fairway crested grass, awnless brome and medic, 1.3-2.63 tons/ha for the two-component grass mixture of awnless brome and fairway crested grass and 9.5-10.9 and 4.0-5.7 tons/ha for the legume-grass two-component mixtures (medic+awnless brome and fairway crested grass+Hungarian sainfoin) respectively.

The primary sod layer treatment by disk tillers on the third year provided the yield increase by 1.1 tons/ha for herbage, 0.3 tons/ha for hay and the production of feed units amounted to 0.1 tons/ha. In comparison to the control variant, sod layer treatment together with seeding different types of the herbage mixtures increased the yield of grass stand by 2.5 – 9.9 tons/ha and of hay by 0.7 – 2.5 tons/ha and the production of feed units from 0.4 to 1.0 tons/ha.

In case of direct seeding of herbage mixtures the yield increase, as compared to the natural plot of grasslands, was equal to 1.6-7.8 tons/ha for herbage, 1.5-2.8 tons/ha for hay and the production of feed units amounted to 0.8-1.4 tons/ha. By the third year among all the types of herbal mixtures and all the experiment variants the maximum yield was observed in the two-component legume-grass mixture of medic and awnless brome due to high field germination and plants viability, and the minimum in the grass mixture of fairway crested grass and awnless brome.

The two-component legume-grass mixture of medic and awnless brome showed the best balance of the components providing the maximum yield of herbage, hay and production of feed units for a square unit, as compared to the control variant.

Economic efficiency of the studied methods of improvement was assessed on the basis of a flow process chart with the further calculation of production and material costs.

In order to assess the economic efficiency of the agrotechnical methods applied in the studied variants, the mean figures for hay yield at the natural grassland plot (the control variant), the third-year plot of primary sod layer treatment without seeding, the plot with direct seeding of legume-grass mixtures and plots after the primary sod layer treatment seeded in 2012 are taken into account.

The achieved results show that as compared to the control variant the most profitable is the variant with the primary sod layer treatment and further seeding, it's profitability is equal to 292%. As compared to the control variant, the profitability rate of other variants varies from 126% for the plot with the primary sod layer treatment without seeding to 203 for the plot with direct seeding of herbage mixtures.

Thus, the effected assessment of economical efficiency of the agrotechnical improvement methods showed that on the second year after treatment and seeding of the permanent grasses the profitability of the primary sod layer treatment with dist tillers without seeding is equal to 126%, that of the direct seeding of legume and grass mixtures without sod layer treatment is 203%, and of the primary sod layer treatment by disk tillers and the further seeding of herbage mixtures is 292%.

CONCLUSIONS

1. The analysis of the weather conditions in the course of the study has shown that only one year (2012) of the three can be described as excessively dry, while 2013 and 2014 were rather productive and characterized as slightly dry (1.0-1.1).
2. For the three years of the study the field germination of the permanent legumes and grasses seeded as a part of two- and three-component herbage mixtures varied from 38 to 67 %. Among the studied herbage mixtures the maximum field germination is observed in the two-component herbage mixture of medic and awnless brome. By the beginning of the mowing maturity stage the percentage of preserved plants in different mixtures varied from 92.0 to 99.2% in different years.
3. In the second and the third years of experiment variants the yield of the grass stand after the primary sod layer treatment without seeding amounted to 4.3 tons/ha of herbage and 1.1 tons/ha of hay, on the average for two years. As compared to the control variant (the natural grassland plot) the yield increased by 1.0 tons/ha for herbage and 0.3 tons/ha for hay.
4. On the second year the yield of the permanent grasses, on the average for two years (2012, 2013) amounted to 4.6-12.8 tons/ha for herbage and 1.1-3.2 tons/ha for hay in case of seeding as a part of different herbage mixtures and the variant with direct seeding; and to 5.9-14.2 tons/ha and 1.5-3.6 tons/ha, respectively, in case of seeding after the primary sod layer treatment.

   As compared to the control variant in case of direct seeding of different herbage mixtures the yield increased by 0.3-2,4 tons/ha of hay.

   As compared to the control variant, on the average for two years the maximum yield increase was observed in the variant with seeding herbage mixtures after the primary sod layer treatmwnt and was equal to 5.7-10.9 for herbage and 0.7-2.8 tons/ha for hay in different herbage mixtures.

   As compared to the control variant, on the average for two years the maximum yield increase was observed in the two-component legume-grass mixture of medic and awnless brome in any experiment variant.
5. By the third year (seeding of 2012) in the variant with direct seeding the yield of the permanent grasses in different herbage mixtures was equal to 4.9-11.1 tons/ha for herbage and 1.2-2.8 tons/ha for hay. In the variant with seeding the herbage mixtures after the primary sod layer treatment by disk tillers it increased by 5.8-13.2 tons/ha for herbage and by 1.5-3.3 tons/ha for hay. The maximum yield increase was attained in case of seeding after the primary sod layer treatment and was equal 2.6-9.8 tons/ha for herbage and 1.5-2.8 tons/ha for hay.
6. Assessment of the economical efficiency of the agrotechnical grassland improvement methods showed that the profitability of the primary sod layer treatment by disk tillers without seeding is equal to 126%, that of the direct seeding of legume and grass mixtures without sod layer treatment is 203%, and of the primary sod layer treatment by disk tillers and the further seeding of herbage mixtures is 292 %.

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