ОШ МАМЛЕКЕТТИК УНИВЕРСИТЕТИНИН ЖАРЧЫСЫ. АЙЫЛ ЧАРБА: АГРОНОМИЯ, ВЕТЕРИНАРИЯ ЖАНА ЗООТЕХНИЯ

ВЕСТНИК ОШСКОГО ГОСУДАРСТВЕННОГО УНИВЕРСИТЕТА. СЕЛЬСКОЕ ХОЗЯЙСТВО: АГРОНОМИЯ, ВЕТЕРИНАРИЯ И ЗООТЕХНИЯ

JOURNAL OF OSH STATE UNIVERSITY. AGRICULTURE: AGRONOMY, VETERINARY AND ZOOTECHNICS

e-ISSN: 1694-8696
№4(5)/2023, 1-11

АГРОНОМИЯ

УДК: 631.: 633.2.3.031
DOI: 10.52754/16948696_2023_4_1

STATE OF SOD-PODZOLIC SOIL FERTILITY LOAMY SOIL DURING LONG -TERM HAYMAKING WHEN USING IT

СОСТОЯНИЕ ПЛОДОРОДИЯ ДЕРНОВО-ПОДЗОЛИСТОЙ СУГЛИНИСТОЙ ПОЧВЫ ПРИ ДЛИТЕЛЬНОМ СЕНОКОСНОМ ИСПОЛЬЗОВАНИИ

УЗАК МЕЗГИЛГЕ ЧӨП ЧАБУУДА КОЛДОНУУДА САЗДАК ЧАМЧАК ТОПУРАГЫНЫН АСЫЛДУУЛУГУНУН АБАЛЫ

Teberdiev Dalkhat Malchievich
Тебердиев Далхат Малчиевич
Тебердиев Далхат Малчиевич

doctor of agricultural sciences, professor, Federal Research Center for Feed Production and Agroecology named after "V. R. Williams"
д.с.х.н., профессор, Федеральный научный центр кормопроизводства и агроэкологии им."В.Р. Вильямса"
а.ч.и.д., профессор, «В.Р. Уильямс» атындагы тоют даярдоо жана агроэкология боюнча федералдык илимий борбор
vik_lugovod@bk.ru

Chuikov Viktor Anatolyevich
Чуйков Виктор Анатольевич
Чуйков Виктор Анатольевич

candidate of agricultural sciences, Associate Professor, Federal Research Center for Feed Production and Agroecology named after "V. R. Williams"
к.с.х.н., доцент, Федеральный научный центр кормопроизводства и агроэкологии им. "В.Р. Вильямса"
а.ч.и.к., доцент, «В.Р. Уильямс» атындагы тоют даярдоо жана агроэкология боюнча федералдык илимий борбор
vik_lugovod@bk.ru

Rodionova Anna Vladimirovna
Родионова Анна Владимировна
Родионова Анна Владимировна

candidate of agricultural sciences, Associate Professor, Federal Research Center for Feed Production and Agroecology named after "V. R. Williams"
к.с.х.н., доцент, Федеральный научный центр кормопроизводства и агроэкологии им. "В.Р. Вильямса"
а.ч.и.к., доцент, «В.Р. Уильямс» атындагы тоют даярдоо жана агроэкология боюнча федералдык илимий борбор
vik_lugovod@bk.ru

Sedova Ekaterina Georgievna
Седова Екатерина Георгиевна
Седова Екатерина Георгиевна

candidate of agricultural sciences, Associate Professor, Federal Research Center for Feed Production and Agroecology named after "V. R. Williams"
к.с.х.н., доцент, Федеральный научный центр кормопроизводства и агроэкологии им. "В.Р. Вильямса"
а.ч.и.к., доцент, «В.Р. Уильямс» атындагы тоют даярдоо жана агроэкология боюнча федералдык илимий борбор
vik_lugovod@bk.ru

Matsui Ekaterina Vladimirovna
Мацуй Екатерина Владимировна
Мацуй Екатерина Владимировна

research associate, Federal Research Center for Feed Production and Agroecology named after "V. R. Williams"
науч.сотр., Федеральный научный центр кормопроизводства и агроэкологии им. "В.Р. Вильямса"
илим.кызмат., «В.Р. Уильямс» атындагы тоют даярдоо жана агроэкология боюнча федералдык илимий борбор
vik_lugovod@bk.ru

STATE OF SOD-PODZOLIC SOIL FERTILITY LOAMY SOIL DURING LONG -TERM HAYMAKING WHEN USING IT

Abstract

Morphological changes of sod-podzolic loamy soil during its haymaking use for 85 years are traced. The description of soilofillets under different methods of using grass stands and their influence on plantcover, as well as morphological changes in the sod-humus horizon, is carried out. It was found that the presence of a sufficient amount of biomass or crop residues with the con-stant use of mineral fertilizers (N120P60K90) contributed to an increase in the sod-illuvial horizon and a decrease in the podzolic one, but the presence or lack of it did not significantly affect the acidic background of the soil of the experimental site. The content of humic substances in the soil, mobile forms of phosphorus and potassium in natural conditions (reserved) largely depended on the volume of biomass, but the highest value of these indicators in the experiment was obtained in the variant with the use of mineral fertilizers. Migration of nitrogen, calcium, and magnesium was observed. The maximum content of mobile forms of phosphorus and potassium was found in the humus horizon up to 30 cm. A common feature of mineral elements is the presence of two horizons with the maximum content: in the sodм and transitionalм to the soil-forming rock.

Key words: *sod-podzolic soil, agrochemical indicators, soil profiles, haymaking, herbage, mineral fertilizers.*

Состояние плодородия дерново-подзолистой суглинистой почвы при длительном сенокосном использовании

Аннотация

Прослежены морфологические изменения дерново-подзолистой суглинистой почвы при ее сенокосном использовании в течение 85 лет. Проведено описание почвенных про-филей при разных способах использования травостоев и их влияние на растительный по-кров, и морфологические изменения в дерново-гумусовом горизонте. Установлено, что наличие достаточного количества биомассы или пожнивных остатков при постоянном применении минеральных удобрений (N120P60K90) способствовало увеличению дерново-иллювиального горизонта и уменьшению подзолистого, но наличие или ее недостаток не существенно отражалось на кислотном фоне почвы опытного участка. Содержание в почве гумусовых веществ, подвижных форм фосфора и калия в естественных условиях (заповедный) в значительной мере зависел от объема биомассы, но наибольшее значение этих показателей в опыте получено в варианте с применением минеральных удобрений. Наблюдалась миграция азота, кальция, магния. Максимальное содержание подвижных форм фосфора и калия находилось в гумусовом горизонте до 30 см. Отмечена общая для минеральных элементов особенность – наличие двух горизонтов с максимальным содер-жанием: в дерновом и переходном к почвообразующей породе.

Ключевые слова: дерново-подзолистая почва, агрохимические показатели, почвенные профили, сенокос, травостой, минеральные удобрения

Сод-подзолик топурагынын асылдуулугунун абалы узак мезгилден чеп чабууда чамчак топурак колдонууда

Аннотация

Саздуу-подзолдуу чополуу топурактын морфологиялык өзгөрүүлөрү аны чөп чабуу үчүн 85 жыл колдонуу учурунда байкалган. Топурак профилдерин сыпаттоо чөп өстүрүүнү колдонуунун ар кандай ыкмалары жана алардын өсүмдүк катмарына тийгизген таасири, чым-чиринди горизонтундагы морфологиялык өзгөрүүлөр үчүн жүргүзүлгөн. Минералдык жер семирткичтерди (N120P60K90) үзгүлтүксүз колдонуу менен биомассанын же өсүмдүк калдыктарынын жетиштүү санда болушу чөп-иллювиалдык горизонттун көбөйүшүнө жана подзолдук горизонттун азайышына шарт түзгөнү аныкталган, бирок анын болушу же жетишсиздиги тажрыйба участогунун кыртышынын кислоталык фонуна олуттуу таасир тийгизбейт. Табигый шартта (запас) кыртышта гуминдик заттардын, фосфордун жана калийдин кыймылдуу формаларынын мазмуну негизинен биомассанын көлөмүнө жараша болгон, бирок экспериментте бул көрсөткүчтөрдүн эң жогорку мааниси минералдык жер семирткичтерди колдонуу менен вариантта алынган. . Азоттун, кальцийдин жана магнийдин миграциясы байкалган. Фосфор менен калийдин кыймылдуу формаларынын максималдуу мазмуну 30 смге чейинки гумустун горизонтунда табылган. Минералдык элементтердин жалпы өзгөчөлүгү - максималдуу мазмуну бар эки горизонттун болушу белгиленген: чөптө жана топурак түзүүчүгө өтүүчү кыртыш..

Ачкыч сөздөр: чөптүү-подзолдук топурак, агрохимиялык көрсөткүчтөр, кыртыштын профилдери, чөп чабуу, чөптөр, минералдык жер семирткичтер

Introduction. One of the main conditions for improving the efficiency of agriculture is the preservation and improvement of soil fertility. First of all, this applies to sod-podzolic soils, which are not characterizedтby good fertility. The sod process has not been actively developed and, even with a long-term covering of grassy vegetation, a significant amount of humus and nutrients does not accumulate in the soil. [1].

Low natural potential fertility of sod-podzolic soils is indicated by: acidic reaction of the soil environment (pH KCL = 4.0-5.0); predominance of fulvic acids in humus; weakly expressed non-strong structure of the upper horizons, which can easily be sprayed, float when moistened, and form a crust when dried [2]. In addition, the systematic use of physiologically acidic mineral fertilizers under these conditions led to the destruction of humus, an increaseиin soil moisture content, and depletion of its upper horizons with calcium and magnesium [3], although in numerous studies of employees of the Federal Research Center "V. R. Williams VIC" in long-term experiments on the use of various doses of mineral fertilizers hayfields and pastures did not have a negative impact on the agrochemical indicators of the soil and the quality of feed [4].

The purpose of these studies is to establish the effect of long-term application of mineral fertilizers on the lime background on the structure and agrochemical indicators плодородия of soil fertility during long-term haymaking use.

Research methodology. The object of the study was sod-podzolic loamy soil with the following initialeparameters in the 0-20 cm layer: humus content (according to Knop) – 2.03 %, total nitrogen (according to KarlельDahl) – 0.12 %, K_2O (according to Maslova) - 70 mg / kg, P_2O_5 (according to Kirsanov) – 60 mg / kg, pH of COPL-4.3. Other parameters were not determined.

To achieve these goals, three soil sections were laid on the hayfield, which has not been released since 1935 re - tinning. Soil samples were selected according to variants and genetic horizons. The experience scheme included three options:

I Option I-protected, non-portable, no lime – control.

II Option II – a single application of lime at a dose of 36 t / ha, measures for the care of grass stands;

III Option III – a single application of lime at a dose of 36 t / ha, annual application of $N_{120}P_{60}K_{90}$ and measures to care for the grass stand.

Chemical analyses of the soil were carried out according to GOST: pH of COPL - potentiometrically (GOST 26423-91), the sum of absorbed bases – according to Kappen-Gilkovits (GOST R 27821-2020), humus content – according to Tyurin (GOST 26213-91), mobile forms of phosphorus and potassium (GOST 54650-2011) – according to Kirsanov in the modification of the TSNAO. Total nitrogen content – according to Kjeldahl (GOST 26107-84). To prepare for the analysis, air-dry soil was mechanically crushed and sieved through a 0.25 mm sieve.

Research results. Natural sod-podzolic soil is characterized by a clear division of the profile into genetic horizons hand the presence of felt of various densities and thicknesses on the surface.

In experiment 2, the soil profile of the "protected area" was used for control. In the soil sectionвыражены, 4 horizons are clearly defined:

A_{0-2} cm, litter of semi-rotted plant remains with hyphae of fungi; A_1 humus-eluvial 1-2-18 cm, sod, humus-elluvial horizon of dark color, fragile lumpy structure filled with living and dead roots; A_2 – 18-29 cm, podzolic, eluvial, light gray, structureless, the presence of single rusty; leaves. A_2/ B – 29-53 cm, transitional between podzolic and illuvial, be-forest leaks of the podzol, single dark nodules, compacted, dispersed into plates and lumps; C-53-128 cm, illuvial, transitionaloindentation

horizon, red-brown color, moistened, compacted, prismatic structure; C-soil-forming parent rock-cover loamandnoc on moraine deposits.

According to the" Classification and Diagnostics of soils of the USSR", the soil of the site is characterized as: sod-medium podzol on the cover loam моренныхof moraine deposits.

Comparing the morphological differences of other soil sections with the control, it can be noted that on the variant without fertilizers and annual biomass harvesting (II option II), the development of felt-moss litter of 5 cm was observed, while the sod layer thickness reached 13 cm, which is 3 cm less than the control variant. A negative indicator of thisиhorizon is also a more powerful podzol content of the soil – 18 cm, whileein other experimental variants this horizon did not exceed 10-11 cm.

A more powerful sod horizon was distinguished by the variant with the annual application of full mineral fertilizer ($N_{120}P_{60}K_{90}$), (III option III) inowhich dense sod with a thickness of about a centimeter smoothly passed into the gumuso-elluvial horizon, the value of which at the 85th year of the experiment was 23 cm.

Summarizing the noted morphological features of soil profiles, it can be assumed that during the experiment in the second variant, soil-forming processes seemed to slow down further development due to the lack of favorable conditions, that is, the lack of a sufficient amount of biomass and mineral fertilizers that accelerate itsиmineralization.

During the experiment, the acid background changed accordingнto the variation of the experiment. The humus horizon in the reserve variant, despite the abundance of biomass, retained its acidity at the initial level (pH 4.2-4.3). In other variants, the acidity of the humus layer was determined by limeeintroduced during the laying of the experiment, and was – pH 4.90-4.97. Analysis of genetic horizons for three soil profiles showed that the acidity of sod-podzolic soil has two maxima – in podzolic (A_3) and transitional to cover loam (B / C) (Table. 1), but this is especially noticeable in the background andзyawning.

The higher acidity of the soil solution along the soil profile is probably due to the vertical migration of the main components of lime Ca and mossg.

О вымывании Ca и Mg there are various opinions about the leaching of Ca and Mg after liming. Based on model experiments, it was found that the majority of ionic materials (Ca and Mg) are washed out after a year, andaonly minor losses were observed in the third year [5]. Since Ca enters one qual state with the calcium solution in the soil and becomes resistant to migration, but these cations are washed out in different ways. Calcium is washed out 3-4 times faster, since it does not have barriers to the formationчof secondary silicates, and it is not absorbed by clay and humus colloids in comparison with magnesium [6].

The high mobility of Ca in soils of the leaching water regime is associatedawith a large radius of the Ca ion (1.06 A), which does not allow it to participate in the construction of the crystal lattice of minerals and firmly establish itself in soils, a special quality of humus, in which humic acids have a weak bond to retain Ca in their composition, thereby creating prerequisites for rapid removal of the humus horizon and soil profile beyond the aisles [7]. The higher content of calcareous materials (Ca and Mg) in the transition horizon of soil profiles is also indicated by the data of the sumмof exchange bases S (12-17 mg /eq.) and the degree of saturation of basesa (V). This was observed both on the calcareous background and on the control (Table 1).

Table 1. Agrochemical characteristics of the soil of the experimental site. 2023

Npp	Name of mountain sandumbrella	Horizontal depthн, cm	pH CSL	Humus	N total	With	S:N	S	Ng	V	P_2O_5	K_2O
				%				mEq/100g			%	
protected option												
1	And_1 (groin)	2-18	4,30	3,07	0,17	1,78	10,4	7,3	4,82	60	64	114
2	AND_2	18-29	4,68	OF 1.13	0,30	0,64	2,1	5,2	2,52	67	20	34
3	AND_2IN	29-53	4,26	OF 1.07	0,12	0,62	OF 5.1	TO 11.8	3,79	75	46	76
4	IN	53-85	OF 4.01	0,85	0,32	0,49	1,6	14,7	3,40	81	55	90
5	/s	85-125	5,13	0,59	0,40	0,34	0,85	17,0	of 2.62	86	84	93
without fertilizer												
1	And_1 (groin)	5-18	4,97	2,80	0,19	1,90	9,90	11,7	3,05	79	26	39
2	AND_2	18-36	OF 5.84	1,23	0,13	0,70	5,4	5,3	1,03	83	16	19
3	AND_2IN	36-70	5,22	OF 1.05	0,12	0,60	5,0	12,3	OF 2.74	81	67	76
4	IN/With	70-95	of 5.62	0,96	0,13	0,55	4,2	14,2	2,18	87	76	80
$N_{120}P_{60}K_{90}$												
1	And_1 (groin)	1-23	4,90	3,52	0,19	OF 2.04	10,7	8,0	5,48	60	243	55
2	AND_2	23-35	5,78	0,95	0,15	1.55 V	4,2	6,3	1,53	80	133	28
3	AND_2IN	35-65	5,00	0,87	0,22	0,50	2,2	12,3	3,00	80	53	86
4	IN/With	65-95	5,68	0,80	0,24	0,46	7,90	13,2	2,60	84	80	92

The humus content in the experiment significantly differed from the method of using the grass stand. In the" reserved " version, its contentcincreased from 2.03% to 3.07% during the survey period. In the non – fertilized variants, the humus growth rate was the lowest (0.8%) against the background of winter crops (36 t/ha). The maximum increase in the humus content to 3.52 % was observed in the variant with the constant use of acomplete mineral fertilizer on the background of lime.

Analyzing the results obtained, it can be noted that the growth of humus in the sod layer was influenced by the volume of biomass and root residues.oHowever, according to a number of scientists, plant mass is the main, but not the only factor. In addition to stocks of plant residues, decomposition, which depends on microbiological activity, is important.

Many researchers have paid attention to the role of lime in the process of humus formation. Some of them note the fact that it stimulates the decomposition of fresh plant residues due to a decrease in soil acidity and an increase in microbiological activity. The latter (exchange Ca^{++}) delays the decomposition of humic substances due to the formation humates of Ca humates and the formation of organo-mineral compounds. Depending on their mobility, humus andяrelated minerals accumulate in the upper soil horizons or migratecfrequently along the soil profile [8]. The amount of accumulation of humic substances for each soil is different and is determined by the absorption capacityиof the m and oral colloidal fraction [9].

From the results obtained in the experiment, it follows that humus substances are mainly found in the sod horizon at a depth of 0-20 cm. The migration ofyhy-fungal substances according to the experimental variants was observed up to a depth of 30 cm. At this level, the content of humic substances was (0.95-1.13 %). However, esignificant amounts of humic substances (0.59-0.80 %) were recorded deep in the profile upoto the cover loam.

Layer-by-layer studies of the sod horizon in variant No. 3 showed that up to 68% of humus substances are concentrated in the upper layer of 0-10 cm. Theohumus content in it was 3.88 % versus 2.65 % in the 10-23 cm layer. It can be assumed that the migration of some more mobile compounds of humus substances along the soil profile still takes place.

One of the main indicators of humus quality is theeratio of carbon to nitrogen (with: N), the lower it is, the more nitrogen-rich the humus is. For sod-podzolic medium loamy soils, this indicatorвis 9, 5-11, 0. The presented research results (tab. 2) showed that the value of this indicator for the sod horizon of 0-20 cm according to the experimental variants is at the level of 9, 9-10, 7, which can be considered optimal. Down the profile, the C: N ratio decreases dramatically. The reason for this is a decrease in the carbon content of humus and an increase in the nitrogen concentration in the lower soil horizons.

Table 2. Agrochemical characteristics of the soil of the experimental site. 2023

Npp	Nameaof mountainsandumbrella	Horizontal depthн, cm	pH CSL	Gumus	N total	C	C:N	S	Ng	W	P_2O_5	K_2O
				%				mg-eq/100g			%	
$N_{120}P_{60}K_{90}$												
1	A_1 groin	0-10	4,2	3,88	0,19	2,25	11,3	8,5	5,48	60	318	67
2	A_1 groin	10-23	4,9	2,65	0,15	1,54	10,3	8,0	2,80	74	147	39

The total nitrogen content in sod-podzolic loam soil ranges from 0.10-0.18 %. In the experiment, the total nitrogen content in humus horizonswas at the level of 0.17-0.19 %. Its higher concentration (0.32-0.40 %) was observed in the control (reserve) variant in the lower horizons of the soil section. The use of mineral nitrogen ($N_{120}P_{60}K_{90}$) did not affect its accumulation in the sod horizon, but, as in the control, an increase in its content was observed in the lower horizons of the soil profile. Therefore, it can be noted that the main source of soil nitrogen replenishment in natural conditions is plant aboveground and root residues and their subsequent humification. The difference in nitrogen content between the control – 3.07% and the mown variant withoutбfertilizers on the background of lime – 2.8 % is probably associated with different biovolumes of biowass between the variants involved in the formation of humic substances.

The migration of nitrogen along the soil profile to the lower mountain sand umbrellas noted in the experiment was observed in the studies of many authors. Some of them, based on the obtained data, claim that mineral nitrogen in infiltrate solutions is represented by up to 80% of the nitrate form (NO_3), which easily migrates up to ground water [11-0].

The content of mobile phosphorus in the soil was largely indetermined by the way the herbage was used.

In the non-portable variant, the content of mobile phosphorus was atanacute level (60-64 mg/kg) from the time of the experiment. According to some data, grass mixtures with a phosphorus

content of 0.2-0.3 % during their mineralizationaare not able to replenish its supply in the soil, since these amounts of phosphorus are completely used by microorganisms, and there are no other sources ofyphosphorus deposition in the soil, except for the use of mineral fertilizers exists [11, 12].

In the variant without fertilizers and the annual alienation of grass stands, the concentration of mobile phosphorus did not exceed 25 mg/kg, which indicates that theosoil is enriched with this element.

Systematic application of phosphorous fertilizers (P_{60}) has enriched the humus horizon to a high level (243 mg / kg). An increased contentaof mobile phosphorus was also observed in the podzolic horizon (133 mg / kg) at a depth of up to 35 cm, although in other variants of the experiment, its minimum was noted at this level (16-20 mg / kg).

Many scientific papers have been published on the interaction of phosphorus with soil. On sod-podzolic loamy soila, the migration of phosphorus along the profile down every 5 cm to a depth of 60 cm and from bottom to top from 85 to 60 cm was studied. In both cases, it was found that phosphorus does not move more than 10-12 cm from the application site.

There are a number of other studies that were conducted during crop rotations. The authors noted that with prolonged use of phosphorous fertilizers and a sufficient amount of atmospheric precipitation, phosphorus from the humus horizon can migrate along the profile up to 50 cm. Analogsчof these studies in the conditions of hayfields and pastures were not found.

The experimental studies on the distribution of phosphorus over the soil profile showed that in the I and II variants without fertilizers, two of its maxima are observed: in the humus and transition (W/S) to the soilo-forming zone, the upper horizon is inferior in terms of mobile phosphorus contentcto the lower one, where its concentration is 75-80 mg/kg.

In the variant with constant use of phosphorous fertilizers (P_{60}), the concentration of mobile phosphorus in the humus horizon increased to 243 mg / kg. An increased level of mobile forms of phosphorus was observed in both the illuvial horizon at a depth of up to 35 cm. Further, the phosphorus mobility decreased to the transition horizon (W / S) to the soil-forming rock. The second maximum of phosphorus content in the soil was recorded at a depth of 80-95 cm. At this level, all three soil sections showed a decrease in the acid content of theиsolution to pH 5.1-5.7 and a sharp increase in the amount of exchange mineral deposits to 12-17 mg /eq. x is mainly represented by calcium and magnesium. This explains the decrease in soil acidity and increased phosphorus mobility. However, for many types of meadow and field crops, mobile phosphorus is not readily available at this depth. Individual roots in the soil profile were marked only at the level of 50 cm when describing soil sections. Analysis of the humus horizon in layers 0-110 and 10-20 cm showed that more than 55% of mobile phosphorus is concentrated in the 0-10 cm layer. The content of its mobile forms was recorded at the level of 390 mg / kg. Below, but with такthe same high content (143 mg / kg), a layer of 10-20 cm was characterized (Table 2). Consequently, the main amount of phosphorus supplied with mineral fertilizers in haymaking conditions is recorded by humus substances of the soil in the 0-20 cm layer. With the constant use of phosphorous fertilizers up to 60 kg / ha, its migration along the soil profile in conditions of haymaking andchay use is possible up to 30-35 cm.

The content of exchangeable potassium in humus horizons in all threeavariants of the experiment largely depended on the method of using grass stands. In the reserve variant, the concentration of exchangeable potassiumяwas 114 mg / kg, while in the non-fertilized variant and the annual increaseyin herbage, this indicator of soil fertility was three times lower – 39 mg/kg. The variant with systematic application of potash fertilizers was also characterized by a low potassium contenta. The use of mineral fertilizers (K fertilizers (K90) contributed to an increase in the content

of exchangeable potassium in the Humus horizon (Table 1). 1) from 39 to 55 mg / kg, but remained very low.

Consequently, in natural conditions (protected) grass stands without depletionжare able to provide annually the level of exchangeable potassium in the soil sufficient to feed subsequent grass stands without reducing soilofertility. Other options for using grasslands, even with the use of mineral fertilizers at a dose of K90, do not provide even the average level of exchangeable potassium in the soil. This indicates a high demand of meadow grasses for potassium. According to research conducted by the All-Russian Research Institute of Feed, plants can use up to 70 % of the applied potash fertilizers in the first year of the experiment [13]. Some part (14-82 %) of potassium is permanently absorbed, and a very small amount of it can migrateoto a depth of 60 cm [14]. To maintain the initial content of exchangeable potassium in the soil, taking into account the removal of plants, it is required to annually apply 130 kg/ha of potash fertilizers.

The analysis of genetic horizons showed that the exchange potassium content has two maxima – in the humus horizon (A) and in theetransition horizon (B/C) to the soil-forming rock, where the potassium content can increase to 80-95 mg / kg. A distinctive feature in the distribution of potassium along the profile is that the exchange potassium is practically not fixed in the illuvial horizons. Its content was determined at the level of 19-28mg / kg. This is probably due to the low content of clay minerals that can fix potassium in the mountain and umbrella.

Conclusions. Methods of using grass stands in long-term experiments on haymaking had a significant impact on vegetation and morphological features of the sod-humus horizon:

There was a modification of the top layer of sod in the version with out fertilizers and the annual alienation of the grass stand. The development of felt-moss litter up to 5 cm thick was observed.

The presence or sufficient amount of crop residues of grass andopermanent use of mineral fertilizers during long-termause of hay contributed to an increase in sod-humus and a decrease in the size of the illuvial horizons by 1-3 and 5 cm, respectively.

The presence or lack of vegetation in the experiment did not affect the value of the initial acid background of the hay field soil (pH 4.2-4.3). Its value was determined by liming at a dose of 36 t / ha before starting the experiment, owhich continues to maintain the acidity of the humus horizont не a pH of 5.0 for 85 years.

In the experiment, the acidity of the sod-podzolic soil of the hay field had two maximum values – in the illuvial (A_2) and transition (B / C), and the value increased down the soil profile to pH 5.5-5.7, which is explained by the migration of calcium and magnesium.

All the studied methods of long-term use of grass stands in the experiment contributed to the accumulation of humus in the sod horizon, but its maximum content was determined in the variant with the systematic use of mineral fertilizers (from 2.03 % to 3.52 %).

Humus substances in the haymaking soil are unevenly distributed. More than 80 % of them are recorded in the 0-10 cm soil layer. Humus migration was observed only up to a depth of 30 cm. A very small amountyof humic substances (0.59 %) was determined over the entire soil profile up to the cover of loam.

The content of mobile forms of phosphorus and potassium in naturalиconditions was largely determined by the volume of biomass.

In the variant without alienation of the grass stand, the value of mobile forms of fo with fo remained at the same level during the entire observation period. The presence of biomass also had a positive effect on the content of exchangeableapotassium. Its reserves are marked at an average level.

In the case ofимineral fertilizers, the mobility of phosphorus and potassium was determined by the peculiarities of the interaction of each of them with the soil: the main amount of phosphorus was fixed by the humus horizon in the 0-20 cm layer; the potassium dose (K90) contributed very slightly to its accumulation in the upper horizon, which is associated with significant consumption by plants and probably nota sufficient dose. A common feature of mineral elements is the presence of two maxima of content, in the sod (A_{A1}) and first (B/C) horizons to the soil-forming rock. Both elements are prone to minor migration along the profile to a depth of no more than 0-30 cm.

Literature

1. Ponomareva V. V. Humus and soil formation / V. V. Ponomareva, T. A. Plotnikova / / L. - 1980. - p. 222.
2. Lukin S. V., Prozina E. N. Monitoring of soil acidity in the Central Federal District of Russia // Achievements of science and technology of the agroindustrial complex-2019. - T 33, - No. 4, - p. 8-11.
3. Litvinovich A.V., Pavlova O. Yu. Transformation of the humus composition of sod-podzolic soils of light granulometric composition under the action of increasing doses of lime and in the postagrogenic period / Litvinovich / Pochvovedenie-2010, No. 11, pp. 1362-1369.
4. Teberdiev D. M., Rodionova A.V. Efficiency of fertilizers on long-term haymaking // Forage production, 2015, No. 10, pp. 3-7.
5. Litvinovich A.V., Lavrishchev A.V., Bure V. M., Pavlova O. Yu. Intensity of calcium migration from sod-podzolic sandy loam soil produced by various doses of meliorant (according to the model experience). Litvinovich, 2015, No. 6, pp. 84-89.
6. Salaev I. V., Litvinovich A.V. Intensity of migration of calcium and magnesium from sod-podzoliclight loamysoil reclaimed by large fractions of crushed stoneдproduction screening // Litvinovich. - 2018. - No. 2, - pp. 22-28.
7. Bakina L. G., Drichko V. F. Interaction of humic acids of sod-podzolic clay soil with calcium / Bakina L. G. // Soil science. - 2011. - Vol. 44. - No. 12. - pp. 1333-1342.
8. Sychev V. G., Shafras L. G., Vinogradova S. B. Plodorodie pochv Rossii i puti ego regulirovaniya [Soil fertility in Russia and ways of its regulation]. - 2020. - No. 6. - p. 3-33.
9. Shafran S. A., Ermakova A. A., Semenova A. I., Yakovleva T. A. Dynamics of nutrient content in sod-podzolic soils in long-term field experiments. – 2020. – №4 (115). – P. 7-9.
10. Postnikov P. A., Popova V. V. Migration of mineral nitrogen in sod-podzolic soil (lizandmetric experience). / P. A. Postnikov, V. V. Popova // Plodorodie, - 2019. - no. 1. – Issue (106). - pp. 26-28.
11. 11. Vasbieva M. T. Phosphate regime of sod-podzolic soil of natural agrophytocenoses / Vasbieva M. T. // Fosfatnyi rezhim sodnovo-podzolistoy pochvy estestvennykh agrofizov i tocenozov [Phosphate regime of sod-podzolic soils of natural agrophages and tocenoses]. - 2021. - Issue 107. - pp. 92-115.
12. Krasnitsky V. M. Dynamics of mobile phosphorus in the soils of the forest-steppe of Western Siberia and RI / Krasnitsky V. M. , Shmidt A. G., Matveychuk O. A., Bobrenko I. A. Бобренко // Fertility. 2020, No. 2, pp. 57-60.
13. Privalova K. N. Efficiency of potash fertilizers depending on the content of exchangeable potassium in the soil / K. N. Privalova / Innovative technologies in adaptive landscape agriculture. - Suzdal. 2015, pp. 257-260.

14. Yakimenko V. N. Change in the content of potassium forms along the soil profile with different potassium balance in agrocenoses / V. N. Yakimenko // Agrochemistry. - 2007. - No. 3. - pp. 5-11.