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Changes in Agrochemical Parameters of Sod-Podzolic Soil Depending on the Productivity of Cereal Grasses of Different Ripeness and Methods of Tillage in the Carpathian Region

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ABSTRACT
Productivity and mowing periods of various cereal grasses on sod–podzolic soil of Pre–Carpathians were studied. The presence of sown grasses with different ripeness periods provides uniform supply of mowing mass from the middle of May till late September and productivity of lands, which is 5.4–6.8 t ha^{-1} of dry mass, exchange energy – 44.1–56.8 GJ ha^{-1} and 3.81–4.87 t ha^{-1} f.u. On the basis of the obtained results, it was found that with increase of tillage depth from 8–10 cm for surface tillage with disk tools to 20–22 cm by plowing, the productivity of all studied species increased by 2–3% on average for three years with fertilization dose of LSD_{05} equal to 0.30 t ha^{-1}. Cultivation of cereal grasses on sod–podzolic soils stipulates improvement of their fertility, in particular increasing indices of nitrogen, phosphorus and potassium.

Keywords: cereal grasses, soil tillage, agrochemical indices, productivity.

INTRODUCTION

Meadow agrophytocenoses are characterized by well–developed root systems which ensure successful long–term usage both in terms of haymaking and grazing. Such sod makes highly effective use of fertilizers, resists degeneration, forms large amount of both aboveground and underground biomass, as well as prevents soil erosion on the slopes [Kurgak, 2010; Tanchyk et al., 2021]. Growth of meadow grass root system and accumulation of root residues were studied by Yarmolyuk et al. [2013], Chețan et al. [2021], Olifirovych et al. [2018], who found that the bulk of the roots (80–90%) is confined in the upper (0–10 cm) horizon of the soil. Frequent usage of grass leads to decrease of the root system. Over the years of long–term meadow grass usage, the growth of root mass increases [Nan Li–li et al., 2019; Yakupoglu et al., 2021; Demydas et al., 2021].

Perennial grasses with well–developed root system and over–ground organs, which completely cover the soil – from spring to harvest time, and do not require mechanical tillage of soil have the greatest positive impact on the structural condition of the soil [Bomba, 2016; Mischenko et al., 2017]. The analysis of the conducted research proves that the roots of meadow grasses are located, generally, in the top layers of soil and sharply decrease below its profile. In natural meadows, root mass in 0–10 cm layer is 5–10 times lesser than in 10–20 cm layer [Karbivska et al., 2020].

In order to preserve and improve soil fertility, as well as increase their resilience to adverse anthropogenic factors (change in physical and chemical properties of the soil), it is necessary to enhance the organic matter content in the soil. Due to a sharp decline in livestock number in Ukrainian farms, it is almost impossible to solve this problem by application of manure. Therefore, it is necessary to find the ways of restoring and maintaining an optimal level of soil. One of the main resources and promising direction in solving this problem may be growing of perennial grasses [Balaiev et al., 2011; Mischenko et al., 2019; Litvinov et al., 2020; Tonkha et al., 2021].

One of the important directions in grass growing is creation of sown high–yielding grasslands based on the usage of perennial cereal grasses. Preference should be given to sowing cereal grasses with various ripeness periods, as legumes are uncompetitive and short-lived on sod-podzolic soils [Bogovin & Dudnik, 2001; Karpenko et al., 2020; Argenti et al., 2021]. Therefore, further intensification of meadow fodder production involves the introduction of new high-yielding varieties of perennial grasses with different ripeness periods into production, in order to organize mowing conveyors on their basis for continuous supply of green mass during the mowing period and stalking up fodders for winter. However, until recently, such issues have not been sufficiently studied [Kurgak & Tovstoshkur, 2008; Kulyk et al., 2020; Litke et al., 2020; Novák et al., 2020; Moldovan et al., 2018; Kvitko et al., 2021].

MATERIAL AND METHODS

The soil cover of experimental land plot is represented by sod–podzolic surface–gleyed soils on the slope of north–western exposition with declivity of 1–3°, GPS tie: latitude 48°56’55’, longitude – 24°41’35’’.

The research was conducted at the stationary polygon of Agrochemistry and Soil Science Department, Faculty of Natural Sciences, Vasyl Stefanyk Precarpathian National University, established in 2011 according to a generally accepted methodology. The soil cover of experimental field is represented by sod–podzolic surface–gleyed soil. The experiment was conducted three times, the accounting area of experimental plot amounted to 25 m^2. Zonalized and promising varieties of cereal grasses were sown: *Phléum praténse* – Carpathian, *Lolium perenne* – Kolomyiska, *Dactylis glomerata* – Stanislavska, *Festuca rubra* – Hoverla, *Phalaris arundinacea* – Kyiv, *Festuca orientalis* – Smerichka, and *Bromus inermis* – Kozarovytsky.

Table 1. The scheme of experiment

Factor A – types of grass by the level of ripeness	Factor B – soil tillage
1. *Dactylis glomerata* 2. *Festuca orientalis* 3. *Lolium perenne* 4. *Bromus inermis* 5. *Festuca rubra* 6. *Phalaris arundinacea* 7. *Phléum praténse*	Plowing 20–22 cm (control) Shallow plowing 16–18 cm Surface tillage (disking) 8–10 cm

The interaction of two factors was studied in the experiment: A – types of grass by level of ripeness; B – soil tillage: conventional plowing to the depth of humus horizon – 20–22 cm, shallow plowing to a depth of 14–16 cm, and surface tillage (disking to a depth of 8–10 cm) (Table 1). The experiment was carried out on the background of $N_{90}P_{60}K_{60}$ application, where the following mineral fertilizers were used: ammonium nitrate (34% a.s.); potassium–magnesium (29% a.s.); superphosphate (19% a.s.).

The meteorological data obtained by the Ivano–Frankivsk Regional Hydrometeorology Center were used to evaluate the weather conditions during the study period.

The agro–meteorological conditions during the study period were characterized by significant fluctuations in temperature regime indices and irregularities in precipitation compared with long–term trends. In 2011, during April, March, and May, the conditions were arid; the average monthly precipitation levels were 33.9 mm, 35.6 mm, and 4.9 mm, respectively, compared to the respective long–term averages of 81 mm, 57 mm and 4.9 mm. During June and July, rainfall was similar to the long-term average. However, in June and July, the amount of precipitation exceeded the monthly norm (136% and 121%, respectively). Termination of plant vegetation was observed on December 5th, when the plants were in the bushing phase. The wintering conditions were favorable, indicating spring restoration of vegetation could begin at the optimum time (the third week of March).

The temperature conditions in 2012 were higher than the long–term average indices. The recorded temperatures reached 2.7 °C by March, 1.8 °C by May, 2.2 °C by June, 2.6 °C by July, 1.3 °C by August, 1.5 °C by September, 1.2 °C by October, and 2.1 °C by November. The spring conditions were favorable for the optimal growth and development of grasses; in April, 69.3 mm of precipitation fell in comparison to the long–term average of 57 mm. This compensated for the low levels of precipitation in May and June (67.5 mm and 71.4 mm, compared to the long-term average of 87 mm and 106 mm, respectively). The precipitation levels during July and August were similar to the long–term average. September and October 2012 were characterized by warm weather; the average daily air temperature reached 15.3 °C for the sowing and seedling period, and 7.1 °C for the seedling and bushing period. October was characterized by warm weather during the day and lower temperatures at night, and only a few days were lightly frosty. The air temperature ranged from 5.0 °C to 12.5 °C, with a maximum of 18.4 °C above zero, and a minimum of 1.0 °C below zero. During November, when bushing and the termination of vegetation took place, the conditions were characterized by over–damping, and the air temperature reached above 10 °C on only a small number of days. In December, 59.5 mm of precipitation fell, 24.5 mm more than the long–term average, which is 75% of the norm.

In March 2013, the weather conditions were unstable; the weather was mostly warm, precipitation was observed in the form of rain and snow; additionally, heavy winds, snowstorms, and fogs were recorded. The average monthly temperature was 1.1 °C, with a maximum of 10.5 °C and a minimum of 17.2 °C below zero. Average precipitation was 92.5 mm, which is 58.5 mm more than the long–term average, or 172% of the norm. The first week of April was cold with precipitation; therefore, it was unfavorable to most crops. Following a rise in temperature, the grasses renewed vegetation on April 4th. However, the conditions for fieldwork were unfavorable due to excessive soil moisture, and stagnation of water was observed in the areas of the field at low level. The weather was warm with light frost and precipitation at night. Overall, the weather conditions were sufficient for the growth and development of grasses. May was characterized by low precipitation and towards the end of the month – by an increase in air temperature and low humidity. This caused the formation of dry winds, which led to a decrease in the productive moisture levels of the arable soil. Reserves of productive moisture in the arable layer of soil were 9–31 mm, and were 132–192 mm at a depth of 1 m, which is almost insufficient for plant growth. Precipitation in May was 44.2 mm, which is 42.8 mm below the expected level. June and July were cool and warm with some short–term precipitation and heavy rainfalls. However, the weather conditions were sufficient for the growth and development of perennial cereals. Reserves in the arable layer of soil during June were within 21–46 mm, and were 135–193 mm at a depth of 1 m. The air temperature (18.5 °C) and precipitation (101.5 mm) were similar to the long–term average. In July, the weather was cool with light rain. The total precipitation was 82.8 mm, which is 33.2 mm below the long–term average, and the average air temperature was 18.8 °C, compared to the long–term average of 18.6 °C.

The research was conducted according to methodology of the Institute of Fodders of NAAS [Babych, 1998]. The agrochemical parameters of the soil were determined at the beginning and the end of experiment in the most contrasting variants in the soil layer of 0–20 cm according to generally accepted methods, namely: humus – according to Tiurin in accordance with DSTU 4289: 2004; nitrogen, easily hydrolyzed by alkali – according to Cornfield in line with DSTU 7863: 2015; movable phosphorus and potassium – according to Kirsanov and Machygin in line with DSTU 4114–2002; pH (salt) – potentiometric method in line with DSTU ISO10390: 2001. Mathematical processing of research results was conducted by using the methods of disperse analysis and variation statistics according to Dospekhov [1985] on PC using the Statistica 6 software.

RESULTS AND DISCUSSION

The basis for creating a strong and complete fodder base for livestock in the considered area are perennial grasses, which, having high productivity and feeding value, rank first among other groups of fodder crops and play important role in preservation of soil fertility.

Traditional types of perennial grasses for creation of grass lands for haymaking on sod-podzolic soil are *Phléum praténse*, *Lolium praténse*, *Dactylis glomerata*, *Bromus inermis*, and *Trifolium pratense*. However, the studies by Bogovin [2001], Kurgak, Shtakal [2018], Yarmolyuk [2013], Argenti [2021] showed that not all types of meadow grasses can provide high and stable

Table 2. Calendar dates of harvest ripeness in sown cereal grasses with different–ripeness (average for grass mixtures the same type in 2011–2013)

Grass type by precocity	Mowings		
	1–st	2–d	3–d
Early–ripening (*Dactylis glomerata*)	25.05 20.05–29.05	9.07 2.07–15.07	20.08 18.08–30.08
Middle–ripening (*Festuca orientalis, Lolium perenne Bromus inermis, Festuca rubra, Phalaris arundinacea*)	6.06 26.05–11.06	22.07 12.07–1.08	6.09 27.08–20.09
Late–ripening (*Phléum praténse*)	16.06 10.06–22.06	5.08 16.07–20.08	23.09 14.09–29.09

Note. In the numerator – average, in the denominator – deviation by the years.

yields in a long run usage of grass. Therefore, the aim of the conducted research was to determine productivity potential, division by mowings of perennial fodder agrophytocenoses with different composition of species depending on the methods of basic tillage of sod–podzolic soil in the Carpathian region of Ukraine.

Timing of mowing grass for hay, haylage or green fodder, especially in the first mowing, depended on the cycles of seasonal development of dominant components (Table 2). The difference in the coming of harvest ripeness between early and medium–ripening grasses in the 1st moving was 12 days, and between early and late-ripening – 22 days, in the 2nd moving 13 and 27 days respectively, and in the 3rd – 17 and 34 days.

Since the optimal agrotechnical period for harvesting grasses of the same maturing type is on average about 10 days, the presence of different maturing type grasses in the grass conveyor allowed extending the optimal period of harvesting grass in the 1st mowing on average to 32 days, in the 2nd – to 37 and in the 3rd – to 44 days. This has created favorable conditions not only for improving the fodder quality and reducing crop losses, but also for more rational usage of harvesting machines in the system of conveyor fodder production.

According to the research results of various authors who studied peculiarities of crop formation for the first mowing, the increase in dry mass occurs before the phase of mass flowering of dominant cereal components, followed by a decrease in productivity [Kurgak, 2010; Kurgak et al., 2018]. The conducted studies confirmed that the indices of net productivity of photosynthesis reached the highest values at the end of tube making phase and beginning of earing of dominant cereals, and the leaf surface index reached the highest values in the earing phase.

On average, in the first three years of use (2011–2013), a more effective factor in yielding 1 ha of dry mass was grass cover with a share of 77%. Meanwhile, the share of the factor of depth of tillage was 2%. It should be noted that in the first year of life of grasses, the share of influence of a factor of grasses was the lowest and reached 72%. In the 2nd and 3rd years, it increased to 78%. Conversely, the influence of tillage depth slightly decreased over the years. Statistical analysis of cereal grass productivity showed that in 2013 the share of grass factor was 78%, and the share of tillage factor 2%, interaction of AP factors 1%, and the share of residual factors 19% (Fig. 1).

During the analysis of research results, it was found that the productivity of single-species crops of perennial grasses under conditions of different depth of basic tillage for an average of three years ranged from 5.59 to 6.84 t ha^{-1}

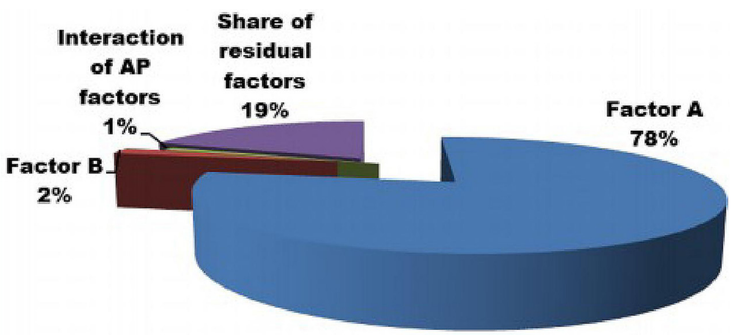

Figure 1. Share of impact factors when growing cereal grasses (2013)

of dry mass, 3.91 to 4.92 t ha^{-1} of feed units, 0.82–1.08 t ha^{-1} of crude protein and 45.3–56.8 GJ ha^{-1} of metabolic energy (Table 3).

Among the studied species of perennial grasses on all variants of tillage, the highest productivity for the first three years of use was provided by *Lolium perenne*. *Dactylis glomerata*, *Festuca orientalis*, *Bromus inermis* and *Phalaris arundinacea* were slightly inferior, but only within the experimental error (0.35 t ha^{-1} of dry mass). The least productive was the medium–ripe *Festuca rubra*, which was 0.43–1.25 t ha^{-1} of dry matter inferior to *Lolium perenne*, *Festuca orientalis*, *Bromus inermis* and *Phalaris arundinacea*. The depth of the main tillage did not affect the productivity of perennial grasses.

Increasing the depth of cultivation from 8–10 cm under the conditions of surface cultivation with disk tools to 20–22 cm by plowing productivity of all studied species increased by only 2–3% on average in three years. The difference in productivity between the average depth (16–18 cm) of tillage, deep plowing (20–22 cm) and minimum disking (8–10 cm) was even smaller.

The change in agrochemical parameters of the soil under cereals is stipulated by the influence of root system and the depth of its penetration into the soil profile. It was found that there

Table 3. Productivity of perennial cereal grasses depending on the depth of main tillage

Grass species and seed sowing norms, kg ha^{-1}	Depth of soil tillage, cm	Dry mass, t ha^{-1}			Average for 2011–2013			
		2011	2012	2013	Dry mass, t ha^{-1}	Feeding units, t ha^{-1}	rude protein, t ha^{-1}	Metabolic energy, GJ ha^{-1}
Early–ripening grasses								
Dactylis glomerata, 16	20-22	5.99	6.40	6.61	6.33	4.56	0.99	51.3
	16-18	5.95	6.33	6.55	6.28	4.52	0.97	50.9
	8-10	5.80	6.22	6.40	6.14	4.36	0.94	49.7
Middle–ripening grasses								
Festuca orientalis, 26	20-22	6.50	6.78	6.81	6.70	4.76	1.01	54.3
	16-18	6.41	6.70	6.75	6.62	4.70	0.99	53.0
	8-10	6.30	6.58	6.63	6.50	4.55	0.98	52.0
Lolium perenne, 26	20-22	6.90	7.30	6.31	6.84	4.92	1.08	56.8
	16-18	6.85	7.25	6.20	6.77	4.87	1.06	55.5
	8-10	6.80	7.12	6.15	6.69	4.82	1.04	54.9
Bromus inermis, 12	20-22	6.08	6.63	6.79	6.50	4.62	0.97	53.3
	16-18	6.00	6.55	6.70	6.42	4.56	0.95	52.0
	8-10	5.90	6.43	6.67	6.33	4.43	0.94	51.2
Festuca rubra, 18	20-22	5.35	5.70	5.75	5.60	3.98	0.82	45.9
	16-18	5.32	5.65	5.70	5.56	3.95	0.81	45.5
	8-10	5.20	5.51	5.60	5.44	3.81	0.79	44.1
Phalaris arundinacea, 14	20-22	6.07	6.68	6.75	6.50	4.49	0.94	51.4
	16-18	6.00	6.62	6.72	6.45	4.39	0.93	51.0
	8-10	5.91	6.51	6.67	6.36	4.32	0.92	50.2
Late–ripening grasses								
Phléum praténse, 14	20-22	5.75	5.75	5.66	5.72	4.06	0.84	47.0
	16-18	5.70	5.68	5.60	5.66	4.02	0.84	46.4
	8-10	5.60	5.63	5.53	5.59	3.91	0.82	45.3
LSD_{05}, t ha^{-1} by factors:								
Grass	0.38	0.35	0.32	0.35				
Depth of soil tillage	0.31	0.29	0.30	0.30				
Share of factors, %:								
Grass	59	57	56	57				
Depth of soil tillage	41	43	44	43				

Note. The experiment was conducted on the background of $N_{90}P_{60}K_{60}$ application

Table 4. Change of agrochemical indices of sod–podzolic soil when growing cereal grasses

Variants of experiment	Plowing, cm	Content of alkaline-hydrolyzed nitrogen, mg kg^{-1} of soil		Content of movable phosphorus, mg kg^{-1} of soil		Content of exchangeable potassium, mg kg^{-1} of soil	
		2011	2013	2011	2013	2011	2013
Early–ripening grasses							
Dactylis glomerata, 16	20-22	67.7	77.9	78.8	82.6	67.1	73.5
	16-18	69.5	79.1	79.3	83.1	73.4	79.9
	8-10	68.5	77.8	78.5	82.3	69.8	76.3
Middle–ripening grasses							
Festuca orientalis, 26	20-22	67.8	77.8	78.4	82.2	67.3	72.9
	16-18	69.5	78.4	79.2	83.2	71.8	77.6
	8-10	68.5	78.1	78.4	82.2	69.5	75.3
Lolium perenne, 26	20-22	67.2	75.8	78.5	81.4	67.1	70.9
	16-18	69.2	77.8	79.1	82.2	72.4	76.2
	8-10	68.4	77.1	78.5	81.4	69.3	73.1
Bromus inermis, 12	20-22	67.6	77.4	78.7	81.6	67.2	71.3
	16-18	69.3	79,0	79.1	82.1	72.6	76.4
	8-10	68.6	77.9	78.3	81.2	69.4	73.2
Festuca rubra, 18	20-22	67.8	77.1	78.9	81.8	67.4	71.2
	16-18	69.4	77.7	79.4	82.3	72.9	76.7
	8-10	68.3	76.6	78.4	81.3	69.9	73.7
Phalaris arundinacea, 14	20-22	67.9	76.2	78.6	81.5	67.3	71.2
	16-18	69.3	77.6	79.3	82.2	70.2	74.0
	8-10	68.6	76.9	78.6	81.5	69.7	73.5
Late–ripening grasses							
Phléum praténse, 14	20-22	67.9	76.5.	78.6	81.5	67.0	70.8
	16-18	69.4	78.1	79.0	81.9	74.0	77.8
	8-10	68.6	77.2	78.2	80.8	69.0	72.7

Early–ripening grasses							
Dactylis glomerata, 16	20-22	67.7	77.9	78.8	82.6	67.1	73.5
	16-18	69.5	79.1	79.3	83.1	73.4	79.9
	8-10	68.5	77.8	78.5	82.3	69.8	76.3
Middle–ripening grasses							
Festuca orientalis, 26	20-22	67.8	77.8	78.4	82.2	67.3	72.9
	16-18	69.5	78.4	79.2	83.2	71.8	77.6
	8-10	68.5	78.1	78.4	82.2	69.5	75.3
Lolium perenne, 26	20-22	67.2	75.8	78.5	81.4	67.1	70.9
	16-18	69.2	77.8	79.1	82.2	72.4	76.2
	8-10	68.4	77.1	78.5	81.4	69.3	73.1
Bromus inermis, 12	20-22	67.6	77.4	78.7	81.6	67.2	71.3
	16-18	69.3	79,0	79.1	82.1	72.6	76.4
	8-10	68.6	77.9	78.3	81.2	69.4	73.2
Festuca rubra, 18	20-22	67.8	77.1	78.9	81.8	67.4	71.2
	16-18	69.4	77.7	79.4	82.3	72.9	76.7
	8-10	68.3	76.6	78.4	81.3	69.9	73.7
Phalaris arundinacea, 14	20-22	67.9	76.2	78.6	81.5	67.3	71.2
	16-18	69.3	77.6	79.3	82.2	70.2	74.0
	8-10	68.6	76.9	78.6	81.5	69.7	73.5
Late–ripening grasses							
Phléum praténse, 14	20-22	67.9	76.5.	78.6	81.5	67.0	70.8
	16-18	69.4	78.1	79.0	81.9	74.0	77.8
	8-10	68.6	77.2	78.2	80.8	69.0	72.7

was an increase in the content of alkaline-hydrolyzed nitrogen to 78.1 mg kg^{-1} of soil in the arable layer of sod–podzolic surface–gleyed soil of the experimental area in the variant with *Phléum praténse* in 2013 with 16–18 cm ploughing (Table 4). The highest amount of nitrogen was in the variant with *Dactylis glomerata* – 79.1 mg kg^{-1} of soil. It is 14–18% more comparing to outgoing indices at sowing time. In turn, the lowest nitrogen content was observed in the variant with *Lolium perenne* – 75.8–77.8 mg kg^{-1} of soil.

The analysis of research results showed that an increase in the content of alkaline–hydrolyzed nitrogen in sod–podzolic soil was observed during the growth of all studied cereal grasses, regardless of tillage variant.

According to the conducted research, there is a low content of movable phosphates in sod–podzolic soil. It was noticed that on average over three years, reserves of movable phosphorus during the growing period of cereal grasses increased.

It is known that the phosphorus reserves in soil are the most stable among other agrochemical indices. Since overgrowing of the territory with perennial grasses allows stopping erosion processes, the content of movable phosphorus in soil increases from 80.8 mg kg^{-1} of soil in the variant with *Phléum praténse* to 83.1 mg kg^{-1} of soil in the variant with *Dactylis glomerata*.

It was established that with cultivation of cereal grasses on sod–podzolic soil its phosphate regime improves as a result of increasing the content of movable phosphorus in the arable layer.

During the research (2011–2013) the following changes were found in reserves of potassium in the soil: in the variant with *Dactylis glomerata* it increased by 6.4 mg kg^{-1} of soil, in the variant with *Lolium perenne* – by 3.8 mg kg^{-1} of soil.

It was found that the content of movable phosphorus and exchangeable potassium increased in all variants of perennial cereal grasses, thus when growing *Festuca orientalis*, *Dactylis glomerata* P_2O_5 increased by 12% and K_2O by 16.4%. Maximum indices were observed for growing *Festuca orientalis* and *Phalaris arundinacea*, where content of movable forms of phosphorus was 83.2–82.2 mg kg^{-1} of soil, exchangeable potassium 77.6–74.0 mg kg^{-1} of soil in the variant with soil tillage deepness of 16–18 cm. The influence of main tillage was determined only in the first years of sowing, and later it was graded due to acquisition of natural agrophysical properties by the soil.

CONCLUSIONS

Among the studied species of perennial cereal grasses in all variants of soil tillage, the highest productivity for the first three years of usage was provided by *Lolium perenne* with the index of 6.84 t ha^{-1} in the variant with plowing depth of 20–22 cm. The *Festuca orientalis*, *Bromus inermis* and *Phalaris arundinacea* species were also most productive, and the least productive were *Festuca rubra*. *Dactylis glomerata* and *Phléum pretense*, which were characterized by an average level of yield. Uniform distribution of the harvest by three mowings was provided by *Dactylis glomerata* with variation coefficient of 6–12%, and the least uniform – *Phléum praténse* (irregularity 29–35%). The difference in coming of harvest ripeness between early and medium–ripening grasses in the 1st mowing is 12%.

The change in the physical and chemical parameters of the soil under cereal grasses is stipulated by the influence of root system and the depth of its penetration into the thickness of soil profile. It was found that the content of movable phosphorus and metabolic potassium increased in all variants of perennial cereal grasses, but when growing *Festuca orientalis*, *Dactylis glomerata* in the variant with P_2O_5, it increased by 12% whereas in the variant with K_2O – by 16.4%.

Cultivation of cereal grasses on sod–podzolic soils stipulates an improvement of their fertility, in particular an increase of indices of nitrogen, phosphorus and potassium. For the Pre–Carpathian zone, it is recommended to create early-ripening grasses with domination of *Dactylis glomerata*, medium–ripening – *Festuca orientalis*, *Bromus inermis*, *Phalaris arundinacea*, *Lolium perenne*, late-ripening – on the basis of *Phléum praténse*.

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