The effect of mineral fertilizers on the yield and quality of hay of leguminous grasses

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Abstract. The article presents the results obtained in the stationary experiment of the Novozybkovskaya SHOS. In the experiment, single-species crops of yellow alfalfa, boneless stalk and grass mixtures based on them were studied against the background of various doses of potash fertilizers (K₁₂₀₋₁₈₀). The influence of potash fertilizers on the yield and quality of legumes and cereals, their mixed crops and a decrease in the content of 137Cs in hay is considered. It was found that the highest yield of hay of perennial grasses in both the first and second mowing was obtained in the P₆₀K₁₈₀ variant. The highest level of hay yield among the studied crops was noted in a grass mixture of yellow alfalfa with a boneless stalk. In terms of the yield of feed units and exchange energy per hectare, the alfalfa + stalk grass mixture exceeded single-species crops. Studies have established that the guaranteed receipt of normatively clean feeds based on yellow alfalfa, boneless stalk and grass mixtures based on them is provided by the use of phosphorus-potassium fertilizer in a dose P₆₀K₁₂₀.

Keywords: yield, potash fertilizers, single-species sowing, mixed sowing, ¹³⁷Cs.

1. Introduction
In modern conditions, field feed production is crucial in creating a solid feed base for animal husbandry. The main object of field feed production is perennial grasses. For animal husbandry, they provide feed, in crop production they contribute to increasing the yield of crop rotation crops, as well as preserving and increasing soil fertility [1].

Up to 10% of the area of perennial grasses are cereals. Their productivity does not exceed 10 t / ha of green mass [2]. The expansion of the area of perennial grasses and an increase in the share of the legume component in grass mixtures is one of the main ways to develop field feed production in Russia in the future. This should significantly reduce the protein deficiency in bulky feeds. When cultivating perennial legumes in single-species and mixed crops, the problem of producing high-protein energy-saturated feeds is largely solved with a fairly significant saving of nitrogen fertilizers [3, 4, 5].

Due to the insignificant specific weight in the structure of the sown areas of feed and grain crops of legumes, the provision of a feed unit with digestible protein does not exceed 80-90 g, which leads to an excess of feed consumption for the production of livestock products by 1.3-1.4 times from the standard [6, 7, 8].

Mixed agrophytocenoses, in contrast to single-species ones, are more closely related to natural phytocenoses in their biological features and, based on this, it is possible to purposefully optimize their
species composition and mineral nutrition conditions in relation to the soil and climatic conditions of the cultivation zone [9].

As a rule, mixed grass stands rationally combine the advantage of cereals and legumes of perennial grasses and are able to provide high and stable yields without the use of expensive nitrogen fertilizers in combination with high feed and nutritional value. This, in turn, largely solves the problem of producing high-protein energy-saturated green and coarse feeds [10, 11].

In the Bryansk region, the situation is complicated by the contamination of feed with radionuclides. Therefore, one of the main tasks of conducting agricultural production in a territory contaminated with radionuclides is to obtain crop production that meets sanitary and hygienic standards. This is the most important condition that causes a decrease in the intake of radionuclides into the human body with food, as well as a decrease in the share of internal radiation [12, 13].

2. Methods and materials

The studies were carried out on the experimental field of the Novozybkovskaya SHOS on sod-podzolic sandy soil with the following agrochemical characteristics: organic matter 1.8-2.1 %, pH_KCl - 5.5-5.8, the content of mobile phosphorus and exchangeable potassium (according to Kirsanov), respectively, 18-22 and 8-10 mg/100 of the soil. The density of soil contamination is 243-324 kBq/m² (9-12 Ki/km²).

The following types of perennial grasses of haymaking use were studied in the experiment: legumes - yellow alfalfa; cereals – boneless stalk. In addition to pure crops, grass mixtures of these crops were studied in the experiment. The total area of the experimental plot is 30 m², the accounting area is 20 m², the repetition of the experiment is 3-fold, the location of the plots is systematic.

The scheme of the experiment provides for the study of the productivity of feed crops in pure single-species sowing and a two-component mixture, depending on the seeding rate, against the background of the following doses and combinations of mineral fertilizers: 1. Control (without fertilizers); 2. P_60 K_120; 3. P_60 K_180. The seeding rate of yellow alfalfa is 6 million. germinating seeds per 1 ha, seedless seedling – 7 million. germinating seeds per 1 ha, in the grass mixture, the seeding rate of the components is reduced by half (3 and 3.5 million germinating seeds per 1 ha, respectively). Types of mineral fertilizers – potassium chloride, simple granulated superphosphate. Field and laboratory studies were carried out according to generally accepted methods. Determination of the content of 137Cs was carried out on the USC "Gamma plus" with the software "Progress-2000".

The meteorological conditions of the growing season in the years of the research differed in moisture content and temperature regime. April-June 2017, April-June were dry, only in July there were isolated rains of a torrential nature. May and two decades of June 2018 were characterized as dry (GTC 0,0-0,7), in the third decade of June and in July there were short-term rains of a torrential nature, which adversely affected the growth and development of plants. Extremely unfavorable weather conditions have developed in 2019. April 2019 was dry, and in the first decade of May, heavy precipitation fell. The first decade of June was characterized as dry.

3. Results and discussion

Mineral fertilizers had an impact on the hay yield of perennial grasses of both the first and second mowing (Table 1). The yield increases of yellow alfalfa in relation to the control in the first mowing, depending on the doses of fertilizers, amounted to 0.31 - 0.98 t/ha. The yield of hay in the second mowing was slightly lower, the increase from fertilizers amounted to 0.25-0.71 t / ha.

The yield of the boneless stalk varied from 1.5 (control, 2nd mowing) to 2.47 t / ha (P_60K_180, 1st mowing) depending on the level of mineral nutrition. The yield of the stalk in the second mowing was 72-77 % of the yield of the first mowing.

Alfalfa-stalk grass mixture in terms of hay yield exceeded pure crops, both alfalfa and stalk-free stalk. The yield of the first mowing from fertilizers increased by 0.80 – 1.54 t/ha, the second-by 0.27-0.71 t / ha.

The maximum yield of hay in the experiment, both single-species crops and grass mixtures, was noted on the P_60K_180 variant in both the first and second mowing.
Table 1. The effect of mineral fertilizers on the hay yield of single-species and mixed crops of forage crops, t / ha (average for 2017-2019)

| version | Yellow alfalfa | Boneless stalk | Alfalfa+starling |
|---------|----------------|----------------|-----------------|
|         | 1 mowing       | 2 mowing       | 1 mowing        | 2 mowing |
| Control | 3.67           | 2.26           | 2.06            | 1.50     |
| P_{60K120} | 3.98           | 2.51           | 2.28            | 1.71     |
| P_{60K180} | 4.65           | 2.78           | 2.47            | 1.91     |

1 mowing HCP_{0.5} 1.09 t/ha, HCP_{0.5} А (grass mixture) – 0.63t/ha, HCP_{0.5} В (fertilizers) – 0.63t/ha
2 mowing HCP_{0.5} 0.50 t/ha, HCP_{0.5} А (grass mixture) – 0.29t/ha, HCP_{0.5} В (fertilizers) – 0.29 t/ha

The calculation of the productivity of feed crops on the basis of laboratory and analytical studies of the biochemical composition of yellow alfalfa, boneless stalk and grass mixtures based on them showed that the yield of digestible protein, feed units, gross and exchange energy was determined both by the level of yield of feed crops and their chemical composition.

On average, for 3 years of research, yellow alfalfa provided the highest productivity in a single-species crop (Table 2). In the first mowing, the yield of digestible protein, depending on the fertilizer system, according to the experimental variants, ranged from 0.30 to 0.37 t / ha, feed units from 2.16 to 2.68 t/ha, the supply of 1 feed unit with digestible protein varied from 131.1 to 167.8 g. The yield of exchange energy was 31.6-39.4 GJ/ha.

The boneless stalk was significantly inferior in terms of productivity to yellow alfalfa, as a legume crop. The yield of digestible protein was 2.3 – 2.7 times lower compared to alfalfa and amounted to 0.13 – 0.14 t/ha. The yield of feed units was 1.14-1.33 t / ha, which is 2 times lower than that of alfalfa. The yield of exchange energy per hectare for the boneless stalk was 32.7-43.3 GJ according to the experimental variants, the provision of a feed unit with digestible protein for the bonfire according to the experimental variants ranged from 81.1-86.6 g.

Table 2. Productivity of the mowing crop of forage crops of the first mowing (average for 2017-2019)

| version | the yield of digestible protein, t / ha | yield of feed units, t / ha | the security of the feed unit, digestible protein, g/k units. | the output of the exchange energy, GJ/ha |
|---------|-----------------------------|-----------------------------|-------------------------------------------------------------|-----------------------------------------------|
|         | yellow alfalfa              | Boneless stalk              | Alfalfa + starling                                          |
| control | 0.30                        | 2.16                        | 131.1                                                       | 31.6                                          |
| P_{60K120} | 0.38                        | 2.34                        | 167.8                                                       | 34.0                                          |
| P_{60K180} | 0.37                        | 2.68                        | 151.2                                                       | 39.4                                          |
| control | 0.13                        | 1.14                        | 81.1                                                        | 17.1                                          |
| P_{60K120} | 0.14                        | 1.25                        | 82.5                                                        | 18.8                                          |
| P_{60K180} | 0.14                        | 1.33                        | 86.6                                                        | 20.3                                          |

The grass mixture of alfalfa + stalk was characterized by higher rates of output of exchange energy and feed units per hectare than in single-species crops of yellow alfalfa and stalk-less stalk. Compared with pure crops, an increase in the yield of exchange energy and feed units per hectare by more than 2
times was noted in the grass mixture of alfalfa with a stalk. The highest productivity of legume-cereal grasses is noted in the variant P60K180.

Environmental safety is the main indicator of the quality of manufactured products in the conditions of radioactive contamination of the soil as a result of the Chernobyl accident.

Gamma-spectrometric analysis showed that, on average, over 3 years of research, the specific activity of alfalfa hay in the control variant exceeded the permissible level of 400 Bq/kg (Table 3). The introduction of potash fertilizer at a dose of 120 and 180 kg/ha against the background of P60 reduced the level of contamination of the feed in relation to the control from 1.3 to 1.9 times in both the first and second mowing. According to the content of 137Cs, the feed met the standard (400 Bq/kg) and is suitable for feeding.

The specific activity of 137Cs in the hay of the boneless stalk on all the studied variants did not exceed the standard. There was a decrease in the accumulation of 137Cs in relation to the control when applying potash fertilizer from 2 to 4.5 times, both in the first and second mowing. Rump, as a cereal crop, has the least ability to accumulate radionuclides than legumes, the content of 137Cs in its hay was 2.3 times lower compared to alfalfa in the control and 4.8 times in the variant with the maximum dose of potassium (P60K180). The effectiveness of potash fertilizer on reducing the transition of 137Cs from the soil to the hay of the boneless stalk was higher than that of alfalfa. Thus, from the introduction of P60K180, the content of 137Cs in the hay of the boneless stalk decreased by 4 times in relation to the control, while in the alfalfa hay – only by 1.9 times.

Table 3. Specific activity of 137Cs in hay of single-species and mixed forage crops (average for 2017-2019), Bc/kg

| Version         | Yellow alfalfa | boneless stalk | alfalfa+starling |
|-----------------|----------------|---------------|------------------|
|                 | 1st mowing     | 2nd mowing    | 1st mowing      | 2nd mowing      | 1st mowing | 2nd mowing |
| control         | 441            | 402           | 188             | 170             | 320        | 298        |
| P60K120         | 330            | 283           | 93              | 86              | 199        | 184        |
| P60K180         | 226            | 212           | 47              | 40              | 173        | 152        |

Note: the permissible level for coarse feed is 400 Bq/kg, VP 13.5. 13/06-01.

The experiment did not record an excess of the maximum permissible level for the content of 137Cs (400 Bq/kg) in feed based on mixed alfalfa crops with a stalk. The content of 137Cs in the mixture of alfalfa + stalk was lower than that of alfalfa in a single-species crop, both in the first and in the second mowing. In comparison with the control, a decrease in the content of caesium by 1.6 – 1.9 times in hay was noted in both mows. The price of 2 mowing shows a lower level of specific activity of 137Cs than in the first mowing.

4. Conclusion

Thus, the highest yield of hay from single-species crops of yellow alfalfa and boneless stalk and grass mixtures based on them was obtained when mineral fertilizers were applied to the dosage of P60K180. The highest productivity of legume-cereal grasses was noted in the P60K180 variant. Guaranteed receipt of normatively clean feed at a soil contamination density of 243-324 kBq/m2 ensures the use of phosphorus-potassium fertilizer at a dose of P60K120. An increase in the dose of potash fertilizer to 180 kg/ha d. v. contributed to a further decrease in the content of 137Cs in hay.

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