Optimal time for sowing mixed summer crops for green fodder

N I Buyankin, A G Krasnoperov

Federal Williams Research Center of Forage Production & Agroecology, Kaliningrad Research Institute of Agriculture, Molodezhny lane, h. 9, Slavyanskoye village, Kaliningrad region, Russia

Corresponding author’s e-mail: kaliningradniish@yandex.ru

Abstract. In most of the territory of the Russian Federation in grain-growing areas, the second half of the growing season (July-August) is more favorable in terms of precipitation and positive temperatures, and by October, summer mixed crops of legumes and cereals can form a fairly large number of green mass. The inclusion of mixed legumes and cereals with different linear growth rates makes it possible to create multi-tiered crops: the lower tier was occupied by lupine and paiza, the upper tier -beans, vetch and peas. This arrangement of plants allows crops to use the energy of sunlight more efficiently and prevent the evaporation of moisture from the soil, especially during the summer sowing period. Quality assessment of the yield of green mass of summer intercropping legume-cereal crop output chromoproteins units per 1 ha showed that late summer time summer mixed sowing has the advantages of not only protein, but also carbohydrates. The maximum collection of protein and forage protein units was obtained in the summer mixed sowing of narrow-leaved lupine, forage beans, spring vetch, forage peas and paiza. Therefore, research on obtaining high-protein green feed for herbivorous farm animals in the late autumn period in the Kaliningrad region is promising and requires careful study.

1. Introduction
From 1993 to the present, in the conditions of the Kaliningrad region on sod-podzolic medium-loamy medium-cultivated soil, studies have been conducted on the comparative study of summer and spring crops of annual long-day crops [1]. The green mass produced in this case will increase the mobile part of fresh organic matter in the soil and reduce its degradation [2,3]. In recent years, various mixtures of lupine, forage beans, spring and winter vetches, and paiza have been studied in field experiments. long-term data On the yield of green mass confirm the effectiveness of summer crops in the Kaliningrad region.

1.1 literature review
Cereals and legumes are the world's main source of high-quality food and feed. Legumes contribute to reducing the amount of greenhouse gas emissions, since they emit 5-7 times less greenhouse gases per unit area compared to other crops [4,5], which can also affect the reduction of global warming [6]. In foreign sources, there is very little information about summer crops of annual legumes and cereals in
the Northern hemisphere. These are mainly crops of various grain crops with peas for green fodder, or oats [7,8].

In Russian sources, summer mixed crops of legumes and cereals are not considered as an independent source of production of full-fledged green fodder in the late autumn period. They are sown after harvesting winter rye (winter wheat, barley, triticale) for green fodder as mown cultivation in two terms (2-3 decades of May; 1-2 decades of June) or after harvesting winter crops for grain (2-3 decades of August) as crop cultivation or ground cover [9,10].

1.2 Problem Statement

Given the gap in research on the optimal timing of summer mixed crops for the productivity of balanced green feed in the late autumn period, it became necessary to study this issue for legumes and cereals when they are grown together, as well as many issues related to agricultural technology remain open. The work on obtaining a nutritionally balanced green feed and crop sideration in the late autumn period is very relevant and is also of great ecological importance for the preservation and improvement of soil fertility in the Kaliningrad region. Therefore, the aim of our study was to determine the optimal timing of summer mixed seeding to obtain a nutrient-balanced green feed in the late autumn period with maximum yield.

To achieve this goal, you had to complete the following tasks:
- to monitor the formation of a sequence in the passage of various phases of legumes and cereals during the formation of the leaf surface;
- to determine and analyze allelopathic effects of legumes and cereals in mixtures during the summer sowing period;
- to evaluate the effect of the longline arrangement of legumes and cereals on the productivity of green mass protein and dry mass yield of the studied plant mixtures at different seeding times;
- develop a scheme for the most optimal joint cultivation of forage legumes and cereals in field crop rotations, taking into account summer seeding.

2. Methods and materials

The study of the productivity of cereal and legume mixtures was carried out in 2018-2020 at the experimental field of the Kaliningrad research Institute of agriculture, a branch of the Federal Williams Research Center of Forage Production & Agroecology (Slavyanskoye village, Polessky district, Kaliningrad region).

The soil of the experimental field is characterized as medium-cultivated, sod-weakly podzolic, in terms of mechanical composition medium-loamy on moraine loam, weakly clay, medium-thick, residual-carbonate with a low humus content (1.9-2.1). The reaction of the soil solution is slightly acidic (pH 5.1-5.3). The content of mobile forms of phosphorus and potassium during the years of research changed slightly, the soil is provided with phosphorus (20.5-22.2 mg / g) and potassium (25.0-29.5 mg/g) per 100 g of soil. The seeds in the experiments were etched. Pure and mixed crops of legumes and cereals were cultivated according to the generally accepted technology without the use of plant protection products and mineral fertilizers. The predecessor is winter triticale. The fertilizer background is zero. In field experiments, the following crops were studied: paiza (krasava variety), narrow-leaved lupin (Vityaz variety), fodder beans (amber variety), spring vetch (Yubileynaya 110 variety), fodder peas (pelyushka variety Zaryanka) in different proportions (table 1).

The total area of the plot is 900 m². Accounting area – 100 m². Repeatability – 3-fold. Options – 4. number of plots-12. Total area under the experiment – 10800 m2. In the experiment, phenological observations were made on the passage of the phases of plant development in spring and summer crops. Weeding of experimental plots was carried out manually, without the use of herbicides. Harvesting and accounting of the crop was carried out by mowing the green mass and weighing the accounting area. Accounting for green mass from summer sowing plots was carried out on October 15.
Table 1. Terms and norms of seeding of legumes and cereals in mixed seeding in the field experience, 2018-2020

| Experience option/ seeding period | Name of the crops in mixed planting | Mid-year, July 20 | Late summer, August 01 |
|-----------------------------------|-------------------------------------|-------------------|------------------------|
|                                   | Seeding rate, million pcs. of seeds | Field germination, % | Seeding rate, million pcs. of seeds | Field germination, % |
| 1                                 | Lupine (1.5)+ peas (0.3) + beans (0.3) + vetch (0.1) | 2.2 | 96 | 2.2 | 98 |
| 2                                 | Lupine (1.5)+ peas (0.3)+ beans (0.3)+ vetch (0.1) + payza (2.0) | 4.2 | 96 | 3.2* | 97 |
| 3                                 | Lupin (1.5)+ payza (2.0) | 3.5 | 96 | 2.5 | 98 |
| 4                                 | Lupine (1.5)+ peas (0.3)+ beans (0.3)+ vetch (0.1) + payza (2.0) | 4.2 | 96 | 3.2 | 98 |

In studies of combined agricultural technology, biochemical and agrochemical methods. Analysis of soil samples was carried out according to the following methods: RNA was determined by potentiometric, exchange potassium and movable phosphates in Kirsanov (GOST R 54650-2011), humus – by Tyurin, hydrolytic acidity – by Kappen, the degree of saturation with bases – a computational method, the exchange aluminium – by Sokolov.

All analyses were performed in 4-fold repetition. Statistical data processing was performed in Excel using standard and recommended methods (Khalafyan A. A., 2007). The obtained data are processed statistically and presented as arithmetic averages for the growing season for each crop rotation option.

3. Results and discussion

Based on the conducted research, it turned out that the inclusion of plants with different linear growth rates in mixed crops makes it possible to create multi-tiered crops: in our experiments, the lower tier was occupied by the components lupine and payza, the upper tier-beans, vetch and peas. This arrangement of plants allows crops to use the energy of sunlight more efficiently and prevent the evaporation of moisture from the soil.

One of the leading factors in the problem of increasing plant productivity is to establish the optimal size of the leaf area in crops, which is formed in accordance with environmental conditions. The leaf area in mixed crops was relatively high, with the largest area being observed in the feed mixture in the second variant (78.9 thousand m²/ha) and fourth (91.7 thousand m²/ha) in late summer sowing (table 2).

Table 2. The leaf area according to variants of experience, thousand m²/ha

| Option | Combination of cultures | Leaf surface, ths.m²/ha |
|--------|-------------------------|-------------------------|
|        |                         | Middle-summer sowing (20 July) | Late summer sowing (1 August) |
| 1      | Lupine + peas + beans + vetch | 58.9 | 61.2 |
| 2      | Lupine + peas + beans + vetch + payza | 73.5 | 78.9 |
| 3      | Lupin + payza | 51.3 | 52.1 |
| 4      | Lupine + peas + beans + vetch + payza | 90.4 | 91.7 |

The smallest leaf surface area was observed in a combination of lupine and payza and ranged from 51.3 to 52.1 thousand m²/ha.

The nutritional value and quality of green food cannot be expressed in any one indicator. This assessment should consist of the following data: chemical composition of the feed and its caloric.
content; digestibility of nutrients; total (energy) nutrition; protein, amino acid, mineral and vitamin nutrition.

It was found that the high content of total nitrogen and crude protein (2.77–3.47 and 16.41–18.41 %) differed in legume-cereal mixtures of late-summer sowing, which was due to the activation of symbiotic nitrogen fixation in a favorable period with optimal temperature and humidity. On average, the content in the green mass of the analyzed indicators in the variants with summer sowing was the maximum and varied in sugar content in the green mass from 5.0 to 7.2%, in fat content - from 1.30 to 1.55%, depending on the sowing period and the composition of mixed crops of legumes and cereals (table 3).

**Table 3.** Biochemical composition of green mass of mixed spring-summer crops of legumes and cereals, 2018-2020

| Experience option/ seeding period | Content in green mass, % | total nitrogen | P | K | protein | sugar | fat |
|----------------------------------|--------------------------|----------------|---|---|---------|-------|-----|
|                                  |                          | 2,00           | 0,293 | 3,73 | 14,25 | 5,4 | 1,31 |
| 1 Middle-Summer, 20 July         |                          | 2,10           | 0,296 | 5,45 | 15,44 | 5,5 | 1,32 |
| 2                                |                          | 2,08           | 0,278 | 3,01 | 15,10 | 5,0 | 1,30 |
| 3                                |                          | 2,69           | 0,345 | 5,12 | 15,94 | 5,8 | 1,33 |
| 4 Last Summer, 1 August          |                          | 3,06           | 0,348 | 6,23 | 16,95 | 6,4 | 1,44 |
| 5                                |                          | 3,45           | 0,373 | 6,53 | 17,63 | 6,7 | 1,45 |
| 6                                |                          | 2,87           | 0,325 | 6,06 | 16,41 | 6,9 | 1,38 |
| 7                                |                          | 3,57           | 0,395 | 6,77 | 18,41 | 7,2 | 1,55 |

The maximum dry mass yield of 28.7 kg / ha and protein harvesting of 88.1 kg / ha were provided by late-summer crops in the fourth variant (table 4).

**Table 4.** Yield and feed value of dry mass of legumes and cereals in mixed spring-summer crops, 2018-2019

| Experience option/ seeding period | Dry mass yield, C / ha | Yield of feed units, thousand units / ha | Protein yield, kg / ha | Collection of digestible protein, kg / ha | CPU collection, ths. units / ha |
|----------------------------------|------------------------|----------------------------------------|------------------------|----------------------------------------|---------------------------------|
| 1 Middle-Summer, 20 July         | 24,9                   | 6,65                                   | 46,1                   | 324                                   | 21,5                            |
| 2                                | 25,0                   | 6,7                                    | 62,9                   | 441                                   | 25,4                            |
| 3                                | 24,1                   | 5,56                                   | 52,3                   | 366                                   | 21,1                            |
| 4                                | 25,3                   | 7,1                                    | 68,3                   | 478                                   | 27,4                            |
| 1 Last Summer, 01 August         | 28,2                   | 7,9                                    | 75,2                   | 547                                   | 33,5                            |
| 2                                | 27,7                   | 8,7                                    | 77,3                   | 595                                   | 35,1                            |
| 3                                | 26,8                   | 7,3                                    | 70,8                   | 533                                   | 28,9                            |
| 4                                | 28,7                   | 9,9                                    | 88,1                   | 637                                   | 38,7                            |
| NSR65                            | 1,3                    |                                        |                        |                                        |                                 |

Protein collection per unit area in the experiment also increased by an average of 1.3 times in the summer sowing options compared to the average summer sowing options.

Quality assessment of the yield of green mass of sown legume-grass crops on the yield of protein and chromoproteins units (CPU) per 1 ha showed that in late summer sowing collection of protein was higher in the first embodiment, at 55.8%, in the second embodiment, the 38.2% in the third – 36.9% and
in the fourth is 41.2%. Maximum fee of protein 88.1 kg/ha and chromoproteins units (CPU) 38.7 thousand units/ha was obtained in late summer mixed sowing of lupine, broad beans, spring vetch, forage pea and payza.

Despite the positive results obtained in numerous studies, summer crops of annual crops are still not given a worthy place in agricultural production.

Often, summer crops of annual crops are used in production as "insurance" in case of mass death of spring crops, their unsatisfactory development due to lack of precipitation, and other reasons. In the best case, they are given secondary importance and are recommended to be used as tillage, crop, ground cover or other crops.

4. Conclusion
As a result of the conducted research, it was found that the inclusion of plants with different linear growth rates in summer mixed crops makes it possible to create multi-tiered crops: in our experiments, the lower tier was occupied by lupine and payza, the upper tier-beans, vetch and peas. This arrangement of plants allows crops to use the energy of sunlight more efficiently and prevent the evaporation of moisture from the soil. Late-summer crops of legumes and cereals have a qualitative and quantitative advantage when cultivated for green fodder.

It is established that the leaf area in mixed crops was relatively high, with the largest area was observed in the mixtures with late summer sowing, in the second embodiment (78.9 thousand m²/ha) and fourth (91.7 thousand m²/ha) in combination with narrow-leaved lupine, fodder beans, vetch spring pea forage and pysoy. The smallest leaf surface area was observed in the combination of lupine and payza and amounted to 31.3 thousand m²/ha.

The high content of total nitrogen and crude protein (2.77–3.47 and 16.41–18.41 %) differed in legume-cereal mixtures of summer sowing, which was due to the activation of symbiotic nitrogen fixation in a favorable period with optimal temperature and humidity. The average content in green mass of the analyzed indices on the options with summer sowing was maximum and ranged in sugar content in green mass from 4.9 to 6.32%, in fat content of from 1.28 to 1.45% depending on rate and composition of mixed legumes-cereals.

The maximum dry mass yield of 27.8 C/ha and protein harvesting of 881 kg/ha were provided by summer crops in the fourth variant. The minimum results were obtained in the spring sowing period in the third version of the experiment – 24.1 C/ha and 523 kg/ha, respectively. Protein collection per unit area in the experiment also increased by an average of 1.3 times in the late-summer sowing variants compared to the mid-summer sowing variants.

Quality assessment of the yield of green mass of sown legume-grass crops on the yield of protein and chromoproteins units (CPU) per 1 ha showed that in late summer sowing collection of protein was higher in the first embodiment, at 55.8%, in the second embodiment, the 38.2% in the third – 36.9% and in the fourth is 41.2%. Maximum fee of protein 88.1 t/ha and chromoproteins units (CPU) 38.7 thousand units/ha was obtained in late summer mixed sowing of lupine, broad beans, spring vetch, forage pea and payza.

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