SUMMER MIXED SEEDING FOR GREEN FODDER AS A PRECEDER FOR WINTER AND SPRING GRAIN CROPS

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Abstract: Mixed summer crops are used to obtain green forage in the late autumn period and are very effective precursors for winter and spring crops. The use of summer crops as a precursor for winter and spring crops saturated with legumes, which, thanks to a well-developed, deeply penetrating root system, raise available nutrients into the arable horizon, structure the soil and leave biological nitrogen for forage after harvesting, using nitrifying bacteria in the rhizosphere.

Keywords: mixed crops, green fodder, soil fertility, predecessor, winter and spring crops, pesticide-free technology, nitrifying bacteria.

1. Introduction
At first glance, the problem of selecting the optimal predecessor when forming a crop rotation with winter and spring crops and providing farm animals with green fodder balanced in protein content in the late autumn period has nothing in common. However, we found a new approach and combined these two problems into one, solving it with the help of the original summer mixed sowing technology.

2. Literature review
Known methods and techniques of conducting adaptive landscape agriculture, which provides for the use of green manure crops, cut-off and intermediate crops [1, 2]. In these methods and techniques, there are no clearly formulated tasks and techniques for agricultural technologies for obtaining green mass in the summer and autumn growing seasons.

There is information about the techniques and methods of cultivating leguminous fodder crops in their own crops and in mixed agrophytocenoses, their influence on the reproduction of soil fertility [3, 4].

The disadvantage of these agricultural technologies is that they include traditional cropping systems without the use of summer crops.

Organizationally, pure fallow is most convenient for winter and spring grain crops as a precursor. However, its inclusion in crop rotations in most regions of the Non-Chernozem zone is ineffective from an economic and energy point of view [5].

It has been established that legume-cereal mixtures are ideal for organizing mixed crops, since fodder beans and peas, lupine and vetch have established themselves as good fodder and environmentally
improving crops. Their widespread introduction into the practice of forage production requires optimization of the selection of varieties and the ratio of the components of mixtures [6].

The aim of the work is to substantiate the effectiveness of summer crops of mixed cereal-legume forage crops, as an optimal precursor for winter and spring grain crops, while maintaining soil fertility.

3. Materials and methods
The study of the productivity of cereal-legume mixtures was carried out in 2018-2021. on the experimental field of the "Kaliningrad Research Institute of Agriculture" - a branch of the Federal State Budgetary Scientific Institution "FNTS VIK im. V.R. Williams "(Slavyansko settlement, Polessky district, Kaliningrad region). The studies combined microbiological, biochemical and agrochemical methods [7, 8]. The rhizosphere index in mixed crops was determined by the method of E.V. Dumacheva. [9]. Rhizosphere index (RI) - was defined as the ratio of the content of basic nutrients and pHKCl in the rhizosphere and outside the rhizosphere.

The soil of the experimental field is characterized as medium-cultivated, soddy-weakly podzolic, in terms of texture, medium loamy on moraine loam, slightly gleic, medium-thick, residual-carbonate with a low humus content (1.9-2.1). The reaction of the soil solution is weakly acidic (pH 5.1-5.3). The content of mobile forms of phosphorus and potassium changed insignificantly during the years of research, 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 pickled. 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 fertilizer background is zero. In field experiments, mixtures of the following fodder crops were studied as precursors of spring and winter cereals: paiza (Krasava variety), narrow-leaved lupine (Vityaz variety), fodder beans (Yantarnye variety), spring vetch (Yubileynaya 110 variety), fodder peas (Zaryanka variety pelushka) in different proportions (Table 1).

| Experience variant / sowing time | Name of crops in mixed sowing | Seeding rate, mln. Pes. ssh. seed | Field germination, % | Name of crops in mixed sowing | Seeding rate, mln. Pes. ssh. seed | Field germination, % |
|--------------------------------|--------------------------------|----------------------------------|---------------------|--------------------------------|----------------------------------|---------------------|
| 1                              | Lupine (1.5) + peas (0.3) + beans (0.3) + vica (0.1) | 2.2                              | 96                  | Lupine (1.5) + peas (0.3) + beans (0.3) + vica (0.1) + pise (2.0) | 4.2                              | 96                  |
| 2                              | Lupine (1.5) + peas (0.3) + beans (0.3) + vica (0.1) + pise (2.0) | 4.2                              | 96                  | Lupine (1.5) + Pise (2.0) | 3.5                              | 96                  |
| 3                              | Lupine (1.5) + Pise (2.0) | 3.5                              | 96                  | Lupine (1.5) + peas (0.3) + beans (0.3) + vica (0.1) + pise (2.0) | 4.2                              | 96                  |
| 4                              | Lupine (1.5) + peas (0.3) + beans (0.3) + vica (0.1) + pise (2.0) | 4.2                              | 96                  | Lupine (1.5) + peas (0.3) + beans (0.3) + vica (0.1) + pise (2.0) | 4.2                              | 96                  |

4. Results of the research
It was found that legume-cereal mixtures of late summer sowing were distinguished by a high content of total nitrogen, phosphorus and potassium, which was due to the activation of symbiotic nitrogen fixation in a favorable period with optimal temperature and humidity. On average, the content of the analyzed indicators in the green mass in the variants with late summer sowing was maximum and varied in the sugar content in the green mass from 5.0 to 7.2%, in the total nitrogen content - from 2.87 to
3.57%, phosphorus - from 0.32 to 0.39%, potassium from 6.06 to 6.77%, depending on the composition of mixed crops of legumes and cereals (table 2).

Table 2. Biochemical composition of green mass of mixed summer crops of legumes and cereals in the flowering phase, 2018-2021.

| Batteries / sowing dates | Mid-summer, July 20 | Late summer, 01 August |
|-------------------------|---------------------|-----------------------|
| total nitrogen          | 2 2,1 8 9           | 3,0 3,4 6 7           |
| phosphorus              | 0,2 0,2 0,2 0,3     | 0,3 0,3 0,3 0,3       |
| potassium               | 3,7 4,4 3,0 5,1     | 6,2 6,5 6,0 6,7       |

In summer crops of mixed fodder crops, an increased amount of green mass is observed also in the late summer period of sowing, with a significant amount of organic matter in both the underground and aboveground mass. Thus, the mass of underground root residues during sowing in the late summer period exceeded the same indicator for the average summer sowing period by 8.9 t / ha, and in the aboveground part by 37.2 t / ha. The content of the main nutrients in the rhizosphere of mixed crops of the late summer seeding period was also higher. The highest indicators were found in option 4 and amounted to 189.7 kg / ha nitrogen, 48.4 kg / ha P2O5 and 156.7 kg / ha K2O (table 3).

Table 3. The accumulation of organic matter in mixed summer crops and the content of nutrients in them during the seed filling phase (2018-2021, average values).

| Option / Sowing time | Mass of underground residues, t / ha | Above ground weight, t / ha | Content in the underground part of the rhizosphere, kg / ha |
|---------------------|--------------------------------------|----------------------------|----------------------------------------------------------|
|                     | N P2O5 K2O                            |                            |                                                          |
| 1                   | 6,0 53,9 147,1 31,5 123,7             |                            |                                                          |
| 2                   | 6,1 55,9 149,8 33,3 125,5             |                            |                                                          |
| 3                   | 5,1 49,7 142,8 28,1 121,8             |                            |                                                          |
| 4                   | 6,6 58,5 153,8 30,3 129,5             |                            |                                                          |
| 1                   | 8,0 64,4 151,3 35,8 128,9             |                            |                                                          |
| 2                   | 8,4 63,7 174,2 38,4 138,2             |                            |                                                          |
| 3                   | 7,8 61,2 147,6 30,1 119,5             |                            |                                                          |
| 4                   | 8,5 65,9 189,7 48,4 156,7             |                            |                                                          |

In the soil, most of the nitrogen is bound in organic compounds, so it is not available to plants and usually acts as the main limiting growth factor.

The process of mineralization of nitrogen-containing organic compounds with the release of ammonia is carried out by ammonifiers. An analysis of the physiological functions performed by microorganisms showed that microorganisms that transform nitrogen-containing organic compounds are actively metabolized in the soil of mixed legume-cereal crops. At the same time, the number of ammonifying microorganisms in the soil of summer crops according to the experimental options increases by 1.7 - 2.1 times compared to spring crops, which is probably due to more favorable conditions for microflora for life, when they are more active and produce a large number of easily hydrolyzed connections of root secretions. (table 4).
Table 4. The number of ecological and trophic groups of microorganisms in the soil of cereal-legume mixtures at the middle and late summer sowing dates, 2018-2021

| Microorganisms / sowing dates | Mid-summer, July 20 | Late summer, 01 August |
|------------------------------|---------------------|------------------------|
| Ammonifying bacteria         | 1,4  3  2,5  3,3   | 1,9  4,2  3,8  4,1     |
| Aminoautotrophic bacteria    | 1,2  4,7  3,8  4,1  | 2,7  5,6  5,5  5,7     |
| Oligotrophic bacteria        | 2,5  1,3  1,7  2    | 2,8  2,1  2,5  3,1     |
| Oligonitrophilic bacteria    | 1,5  4,1  4,5  4,9  | 2,8  9,5  3,1  4,2     |
| Actinomycete fungi           | 0,79  1,1  0,88  1,3 | 0,91  1,3  1,2  1,4     |
| Micromycete fungi            | 27  23,7  24,1  27,1 | 22,4  25,2  35,9  19,8 |

Decomposition of cellulose is one of the indicators of biological activity in soil. In mixed crops of legumes and cereals of spring and summer terms, the same pattern is noted - active decomposition of cellulose in variants with a high proportion of legumes. The number of cellulose-destroying microorganisms in the soil of spring mixed crops increases by 1.4; with summer sowing, 1.7 times as compared with the binary third option - a mixture of lupine and paise.

As a result of the analysis of the aggregate composition of the soil, the regularities of changes in the activity of soil microorganisms in soil aggregates of various fractions were established.

According to the data of wet sieving, it was found that the water resistance of the aggregates increases with an increase in the proportion of the legume component. This is the result of soil-rhizosphere processes in leguminous plants in the root zone and outside it. Under conditions of intensive use of arable land with monocultures, a general pattern is a significant decrease in the share of agronomically valuable aggregates. Their most sensitive components include meso-aggregates ranging in size from 2 to 5 mm.

The active activity of beneficial soil microorganisms in agronomically valuable soil particles from 2 to 5 mm led to an increase in soil fertility and yield of green mass in mixed legumes and cereals. During summer sowing, in leguminous plants in the rhizosphere zone, the reaction shifted to the alkaline side, while the level of available forms of nitrogen, phosphorus, and potassium in the root zone increased. The water-physical conditions in the soil in summer in a mixed legume-cereal crop facilitated the penetration of available nutrients into the rhizosphere zone of the root system of the cereal crop - paise, which was reflected in the enhanced development of the aboveground part.

The results of action as predecessors on the amount of grain harvest of winter triticale, winter wheat, spring barley and spring wheat for 2018-2021 are shown in Table 5, which in the conditions of the Kaliningrad region occupy the main areas of grain crops.

Table 5. Influence of summer mixed legume-cereal crops as a precursor for winter and spring grain crops (2018-2021)

| Option / Sowing time | Winter triticale | Winter wheat | Spring wheat | Spring barley |
|---------------------|-----------------|--------------|--------------|---------------|
| 1                   | 5,71            | 4,40         | 3,82         | 3,55          |
| 2                   | 5,76            | 4,44         | 3,84         | 3,58          |
| 3                   | 5,66            | 4,38         | 3,78         | 3,45          |
| 4                   | 5,79            | 4,59         | 4,11         | 3,88          |
| 1                   | 5,98            | 4,57         | 3,89         | 3,71          |
| 2                   | 5,88            | 4,77         | 3,91         | 3,79          |
| 3                   | 5,78            | 4,55         | 3,90         | 3,53          |
| 4                   | 6,01            | 4,89         | 4,15         | 3,95          |
| HCP<sub>0.05</sub> | 0,21            | 0,18         | 0,17         | 0,15          |
As can be seen from Table 5, the grain yield for all four crops is higher in the fourth variant with a late summer sowing period in combination with narrow-leaved lupine, fodder beans, spring vetch, fodder peas and paiza. These indicators are close to the average yield of grain crops in the Kaliningrad region.

Thus, the use of mixed summer crops of legumes and cereals allows to obtain consistently high yields of green mass per unit area, providing economic efficiency and environmental safety of the production of green fodder with a high protein content. At the same time, mixed summer crops of legumes and cereals are a good predecessor for winter and spring grain crops.

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