The prospects of common vetch cultivation in mixed agrocoenoses in the conditions of Novgorod region

K A Ambartsumova
Yaroslav-the-Wise Novgorod State University, 41, ul. B. St. Petersburgskaya, Veliky Novgorod, Russia Federation
E-mail: abdurahmanowa.kamila@yandex.ru

Abstract. For effective creation of highly productive plant formation, at first it is necessary to identify how the participants of this density interact with each other throughout the growth season. By cultivating mixed agrocoenoses, it is possible to identify this relationship and strengthen the food supply by establishing the optimal method of seeding and its seeding rates with different components. This article presents the main results of a scientific study of mixed agrocoenosis of vetch with different components at different seeding methods and seeding rates in the conditions of the Novgorod region. In the studies, the vetch was cultivated in a mixture with oats, and also pure vetch and pure oats were also sown to compare the results. The table shows the ratio of the legume-cereal component in the seeding rate and the influence of the seeding rate on such indicators as field germination rate, plant livability and the density of plants standing before harvesting. In the course of research, it was found that the optimal way to sow mixed agrocoenosis in the field of crops according to such indicators as elements of herbage productivity, field germination and crop yield is a combined method (1:1). Using this method of seeding, the resulting yield of the herbage of the common vetch reached 22.3 tph (tons per hectare) in comparison with the examining variant of the single-species dropping of the vetch.

1. Introduction
Currently, the existing conditions for the development of a market economy in the agricultural sector are determined by such factors as the production and sale of livestock products. But the lack of planning for feed production in many agricultural enterprises leads to a decrease in the feed crops’ yield, which contributes to high costs for the production and purchase of necessary feed to provide them to farm animals. In some farms, primitive technology is still used not only for feeding animals, but also for foraging; hence there is another reason for the loss-making of the feed industry in a number of agricultural enterprises. Rational use and procurement of feed is the main task of improving the efficiency of livestock production, since it is the share of forage procurement that accounts for most of the costs of livestock production [1, 2].

In actual conditions, the food supply does not meet the requirements of intensive development of the livestock industry. At the moment, not only the number of livestock has been reduced, but also the area under cultivation, which leads to a decrease in the productivity of natural forage lands and arable land.

As a science, forage production is the development of theoretical foundations and practical techniques for the formation of a highly effective food supply in an agricultural enterprise, this will lead to a stable increase in the yield of forage crops and agrocoenoses, as a result of which the agricultural enterprise will have a chance to organize optimal planning of forage production and their appropriate use in different soil and climatic conditions on natural and sown hayfields and pastures [3].
One of the measures to strengthen the feed base is the selection of stable high-yielding crops to various types of abiotic and biotic factors, which will allow these crops to become a source of full-fledged feed. Therefore, such a solution to strengthen the forage base can be considered promising, since it is based on a variety of natural conditions, which is expressed by zoning, instability of meteorological conditions and high soil moisture [4].

Considering agronomical, environmental and economical spheres, the most profitable is the correct selection of forage crops, which will give an impetus to improving the efficiency of forage harvesting and obtaining stable high yields in extreme conditions in the zone of risky agriculture. The correct selection of forage crops is based on their cultivation not only in pure form, but also in mixed agroecosystems [5, 6].

Mixed agroecosystems being effective in terms of increasing soil fertility, also provide the maximum yield of crop production per unit area. Very often, mixed agroecosystems are constructed from legumes and cereals. Such mixed agroecosystems have a number of advantages, one of which is that the legume component improves the nitrogen-phosphorus nutrition of the cereal component due to their ability to fix nitrogen from the atmosphere. Also, legumes convert difficult-to-dissolve forms of phosphates into easily accessible forms for cereals, in turn; cereals act as a supporting crop [7].

Legume-cereal mixtures complement each other well on the complementarity principle, avoiding aggressive competition in mixed agroecosystems. In this case, the complementarity of the legume-cereal mixture is due to the different location of the root system in the soil layers, and different resistance to natural stress, as well as different leafiness. Due to the different structure of root systems and the presence of tiers in mixed agroecosystems, a favorable microclimate is created for the growth and development of plants.

Mixed agroecosystems and effective in getting the full nutrition of the feed, as pure crops in terms of protein content is not always superior to the mixed planting. In pure crops of cereals, a crop of green mass rich in carbohydrates, but poor in protein, and, conversely, in pure crops of legumes, you can get a feed rich in protein, but poor in carbohydrates. In addition, mixtures are very well eaten by animals than single pure crops of cereals and legumes [8].

2. Objects and methods of research
The following article is based on the study of the cultivation effectiveness of common vetch with cereals (oats) mixed agroecosystems of to establish the optimal components of the mixture, by cultivating them in different methods of sowing and seeding rates.

Forage crop – vetch – is well suited for growing in the conditions of the Novgorod region, its mixtures make it possible to get a full-fledged nutritious food and it is well eaten by farm animals.

The research work was carried out at the experimental fields of the Institute of Agriculture and Natural resources of Yaroslav-the-Wise Novgorod State University in the conditions of the Novgorod in 2014-2018.

Three variants of different seeding methods of vetch in a mixture with components were studied. To compare the results of the mix variants, we sowed a variant of common vetch seeding and oats in pure form. Method of seeding used – row seeding, alternating rows of vetch with oats, barley and lupine: combined seeding 1:1 and 2:1, mixed – 1+1. The placement of all options in the experiment is randomized, with three-fold repetition. Accounting for yield, observations of phenological and biometric indicators were performed in accordance with the methodological recommendations of All-Russian Williams Fodder Research Institute [9].

Weather data during the study years differed, and not only in temperature, but also on the amount of precipitation and their distribution by months of the vegetation period, it is possible to consider exploring in different weather conditions.

For research, varieties of legumes and cereals were taken: common vetch – Yaroslavskaya 136, oats Borrus. Seeding rates for components are shown in table 1.
Table 1. The ratio of legumes and cereals components in the normal seeding rate for the cultivation of mixed agrocoenoses (average per 2014–2018).

| Seeding method, rows alternating | Component ratio, % | Seeding rate common vetch + oats ml/ha | kg/ha |
|---------------------------------|--------------------|----------------------------------------|-------|
| row seeding                     |                    |                                        |       |
| combined 1:1                    | common vetch (examining) 5.0 | 250                                     |       |
| oats (examining)                | V – 50             | 2.5                                    | 125   |
| combined 2:1                    | O – 50             | 2.5                                    | 100   |
| V – 75                          | 2.5                | 125                                    |       |
| mixed 1+1                       | O – 50             | 2.5                                    | 250   |
|                                | V – 50             | 2.5                                    | 200   |

Considering the data of table 1, representing the ratio of leguminous and cereal components in the cultivation mixed agriculture seeding rate, and analyzing the results obtained in years of research, we are allowed to conclude that for mixed farming of common vetch in mixture with oats there were created comfortable conditions for its growth. Oats acting as a supporting crop for vetch improved the conditions for combined growth, ensuring the development of plants. Throughout the growing season, common vetch developed without lying down, this could lead to rotting of plants and loss of herbage yield. Phenological observations showed that in the mixed agrocoenosis oats improved nitrogen nutrition, in this regard; there was an active increase in vegetative mass.

3. Results and discussion
In mixed agrocoenoses, the relationship between legumes and cereals components in their cultivation is of a great interest. This interest is characterized by such an indicator as the overall survival of plants, which is determined by the components seeding rate, the level of mineral nutrition, field germination of seeds and plant safety during the growing season, which ultimately determines the density of plants standing before harvesting (table 2).

Table 2 shows that field germination in all variants of mixed agrocoenosis was not inferior to these crops in their pure form. So if the field germination rate of the common vetch was at the level of 96.2–98.2 %, which is equivalent to its examining of single-species seeding of the common vetch. With a single-species oat crop, the field germination rate was 81.2%, and comparing this indicator with a mixed agrocoenosis, we can conclude that when cultivating oats in a mixture with vetch, its field germination increased by 8.4 – 4.1% in a combined crop (1:1 and 2:1), and in a mixed 1+1 remained equivalent. However, the obtained data on field germination led the authors to think about the negative impact on the germination of seeds when cultivated in a mixture of legumes and cereals on both the cereal and legume components. This idea they explain the fact that when observing the experience in variants of mixed farming by increasing legume component saw a slight decline in germination cereal, and it decreased proportionally to the increase in the proportion of legume component.

Table 2. Characteristics of pure and mixed agrocoenoses when the different ratio components in the mixture (average per 2014–2018).

| Indicator | Components ratio, % | Seeding method, rows alternating | oats combined 1:1 combined 2:1 mixed 1+1 |
|-----------|---------------------|---------------------------------|----------------------------------------|
|           |                     | common vetch / oats             |                                        |
Regarding the indicator of the plants safety in this experiment, the authors concluded that mixed agroconoses of vetch and oats were at almost the same level as single-species crops of vetch and oats, which acted as a control. In a single-species crop of vetch and oats, plant safety during the period from germination to harvesting remained high and amounted to 98.4% for vetch and 95.1% for oats. According to the research data from leading research organizations, the index of plant safety in mixed agroconoses should decrease as the share of the legume component increases and the share of the support crop decreases, but this fact was not established in our observations, on the contrary, it increased to 3%. Therefore, we can conclude that the two components were correctly selected and they developed throughout the growing season without entering into mutual competition with each other.

It was found that in the studied variants of mixed agroconosis, the seeding rate did not have a significant impact, the maximum density of standing was observed, and mixed agroconoses did not lie down until the harvest of the herbage.

For proper planning of forage production, it is important not only to select the right components, but also to study the biometric indicators of the herbage, which is the way to increase its yield. In the study, the authors also performed such measurements to determine the optimal components ratio of common vetch and oats mix. To do this, we measured the height of plants, counted the number of branches and the number of leaves on one plant in the common vetch, and weighed one plant. The biometric data collected is demonstrated in Table 3.

Based on the results of plants biometric indicators of common vetch, the optimal components ratio will be determined, which can be recommended for implementation in an agricultural enterprise.

So, analyzing the height of common vetch plants in the mixed agroconosis, we can conclude that all the variants of the mixed agroconosis showed equal results, and in comparison with common vetch in pure form, the height measurement indicators were similar. The seeding rate and the seeding method did not affect the results of elements measurements, the number of branches and leaves for mixed crops and single-species crops are equal.

Table 3. Productivity parameters of common vetch plants herbage depending on the seeding method (average per 2014–2018).

| Experiment variants | Seeding method, pow alternating | Plants height, m | Number of branches per 1 plant, pcs. | Number of leaves per 1 plant, pcs. | Herbage productivity, % of control |
|---------------------|--------------------------------|-----------------|--------------------------------------|----------------------------------|----------------------------------|
| Common vetch (control) | row seeding                   | 1.3             | 3.0                                  | 16                               | 66.9                             |
| Common vetch – oats | combined 1:1                   | 1.2             | 2.8                                  | 16                               | 66.9                             |
|                     | combined 2:1                   | 1.1             | 2.6                                  | 15                               | 60.3                             |
|                     | mixed 1+1                      | 1.2             | 1.7                                  | 15                               | 56.7                             |
Study of the herbage productivity parameters of the common vetch from a single plant, the optimal variant was a mixed agroconosis of the combined method of sowing 1:1, the mass of one plant is 66.9 gr. and in relation to the control it means 100%. Comparing the results of Table 3, the 1:1 co-seeding option of common vetch and oats can definitely compete with a single-seeding vetch. The variants of combined 2:1 and mixed 1+1 seeding methods were generally close to the value of control, which can also be offered to farms as an alternative scheme for cultivating mixed crops.

The main task of planning feed production is the cultivation of high-yielding crops with the maximum herbage yield from 1 hectare of area. When cultivating mixed agroconoses, this task takes a back seat, since mixed agroconoses fully provide the main types of animal feed.

As noted above, to obtain the maximum yield of green mass cultivating mixed agroconoses, it is necessary to take into account many determining factors; one of them is the set and correct herbage components ratio. When discussing Table 2, it was already mentioned that an increase in the legume or cereal component led to a proportional decrease in field germination.

Mixed agroconoses of vetch with cereal components in agricultural enterprises are mainly used in the form of green top dressing, silage and hay. The value of the resulting herbage crop of legume-cereal mixture will depend on the level of agricultural equipment and on the phase in which the grass will be mown. Optimal for mowing to a green mass for is the flowering phase-the beginning of bean formation.

Yield is a complex process of interaction between plants and the environment, depending on their genetic potential and habitat resources. Favorable complex natural conditions and the impact of anthropogenic factors affect the plant by changing its productivity parameters. The herbage yield of mixed agroconosis and single-species seeding of the vetch is demonstrated in table 4.

Analyzing Table 4, we found that an increase in the yield of green mass is observed in mixed agroconoses of vetch sown with oats of the joint 1:1 method of seeding – 22.3 tpha compared to the control single – species seeding-16.8 tpha. Mixed agroconoses of vetch and oats in the variants of combined 2:1 and mixed 1+1 seeding methods will also provide an increase of the herbage yield by 14-17% compared to the control variant (table 4).

| Experiment variants   | Seeding method, Row alternating | Herbage yield, tpha | %  |
|-----------------------|---------------------------------|---------------------|----|
| Common vetch (control)| Row seeding                     | 16.8                | 100|
|                       | combined 1:1                    | 22.3                | 133|
| Common vetch – oats   | combined 2:1                    | 19.6                | 117|
|                       | mixed 1+1                       | 19.2                | 114|

4. Conclusion
Making conclusions about the subject, it is important to note that for effective development of forage production and creating a sustainable base for agricultural enterprises it is imperative to implement the planning system of forage, the using the land sustainably. To solve the problem of adequate nutrition of farm animals, it is necessary to cultivate high-yielding and protein-balanced grass stands by cultivating mixed agroconoses.

Having a high biological compatibility of components, mixed agroconoses are recommended to be cultivated to increase the density of herbage, thereby increasing the production of vegetative mass from 1 ha. In mixed agroconoses, vertical layerage is clearly expressed, which allows all participants of the herbage to grow and develop without competing with each other during the entire growing season. Therefore, the cultivation of forage crops with cereal components is very promising.

To obtain a high yield of vetch herbage, it should be cultivated combined with oats 1:1, as a result of which the yield, field germination, safety and density of standing plants up to harvesting have increased. Variants of combined 2:1 and mixed 1+1 sowing of oatmeal can also be offered to farms as an alternative scheme for cultivating mixed crops.
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