Prospects for the Cultivation of Vicia Sativa L. in Mixed Crops on Green Manure in Novgorod Region

K A Ambartsumova
Yaroslav-the-Wise Novgorod State University, ul. B. St. Petersburgskaya, 41 Veliky Novgorod, Russian Federation
E-mail: Kamila.Ambartsumova@novsu.ru

Abstract. Interest in the cultivation of mixed crops increases every year in proportion to the growth of the appearance of problems associated with the deterioration of soil fertility, the rise in the cost of resources and the strengthening of weather anomalies in the country. The problem of decreasing soil fertility and the continuing increase in prices for mineral fertilizers will eventually lead to the introduction of alternative methods of accumulating humus in the soil using low-cost technologies in forage production. In our country, in which the path of intensive development of animal husbandry has been chosen as the main industry in agriculture, feed should make up 80% of all products obtained from agriculture. Studies on the cultivation of vetch (Vicia sativa L.) for green manure purposes have shown that thanks to the deep root system of the vetch-green manure, the soil loosens naturally without the need to dig up arable land. Rotting in the ground, the root leaves empty areas filled with water and air. The conducted studies of the use of vetch in mixed crops for green manure purposes allow recommending joint sowing 1:1 (through a row) vetch with oats as an alternative way to single-species sowing of vetch.

1. Introduction
In the modern world, farming technology is based on monocultures, but nature itself offers mixed crops to us, since everything grows in symbiosis in natural lands and it is extremely rare to find herbage that includes only one crop. According to scientists and individual practitioners, it is assumed that interest in the cultivation of mixed crops will increase every year in proportion to the increase in the appearance of problems associated with the deterioration of soil fertility, the rise in the cost of resources and increased weather anomalies in the country [1].

The problem of decreasing soil fertility and the continuing rise in prices for mineral fertilizers will eventually lead to the introduction of alternative methods of accumulating humus in the soil using low-cost technologies in forage production [2]. In our country, in which the path of intensive development of animal husbandry has been chosen as the main industry in agriculture, feed should make up 80% of all products obtained from agriculture. To solve this problem, feed should be not only in sufficient quantity, but also of high quality and balanced in nutritional value. In this regard, a radical restructuring of the feed industry is required with the introduction of new progressive technologies to obtain high-quality feed for farm animals (silage, haylage and hay). One of their main progressive technologies is the introduction of mixed crop cultivation technology into farms [3].

Co-cultivation has been used for millennia by smallholder farmers across Asia and Europe, Africa and Latin America and is now gaining attention for its ability to produce high yields at lower costs (such as nitrogen fertilization) and its potential to save cropland ... Proponents of mixed crops believe that the
main role in increasing crop productivity should be assigned to natural processes that optimally adapt to specific landscapes [4].

The interaction of cereals and legumes is especially recommended for additional accumulation of nitrogen, while both cereals and legumes receive nitrogen from the soil solution, but only legumes bind nitrogen additionally from the air through symbiosis with nitrogen-fixing bacteria in root nodules. When soil nitrogen is low, cereals perform better in a mixture with legumes than in single-species crops because of the impairment of nitrogen supply, since legumes get some of their nitrogen from the air. Co-cultivation of legumes with cereals can also increase the proportion of nitrogen obtained by legumes from the air [5]. Thus, mixed sowing of cereals and legumes with a low nitrogen intake reduces nitrogen stress in cereals and enhances biological nitrogen fixation of atmospheric nitrogen by legumes [6].

Studies by foreign scientists have identified such a concept as the land equivalent ratio (LER), which is used to assess the benefits of yield in the joint cultivation of crops [7]. This ratio is defined as the sum of the relative yields of crop components. LER is best interpreted as the relative area of land required to grow single species crops to achieve the same yield as the area of catch crops. A LER value greater than one means that mixing crops uses more land efficiently than when cultivating single crops [8, 9].

Research on the cultivation of vetch (Vicia sativa L.) for green manure purposes has shown that, thanks to the deep root system of the vetch-green manure, the soil loosens naturally without the need to dig up arable land. Rotting in the ground, the root leaves empty areas filled with water and air.

At the same time, soil microorganisms that participate in the processing of organic matter multiply better. During digging up the soil, the beneficial microflora is partially destroyed – it dies in ultraviolet rays and when the topsoil dries out.

Alkaloids – vicin and vicinin – disinfect the soil and reduce acidity. No signs of damage to vegetables and root crops by wireworms and nematodes were observed in plantings where vetch was the predecessor.

In addition, vetch has all the necessary requirements for green manure crops, namely Vicia sativa L. grows rapidly and in a short period of time can form a large amount of green mass and is a valuable agricultural crop in terms of chemical composition [10].

2. Research methodology
The formation of a balanced agrocenosis in the cultivation of leguminous crops is relevant for the Novgorod region. In this regard, the goal was set – to determine the components of a mixture of annual legumes and cereals for use as green manure, taking into account various methods of sowing in the conditions of the Novgorod region.

In the course of the research, experiments were laid in 9 variants of different methods of sowing vetch with oats, spring barley and narrow-leaved lupine. The sowing method included alternating rows with joint sowing in the proportion 1: 1 and 2: 1 and mixed – 1 + 1. The placement of the variants is randomized, the repetition is threefold. Yield accountings, observation of phenological and biometric indicators were carried out in accordance with the methodological recommendations of the Federal Research Center “All-Russia Fodder Institute after V.R. Williams”.

3. Results
In mixed crops, all components interact with each other to create a favorable microclimate for the growth and development of mixed grass. The vetch plants, thanks to the grain components, developed without lodging, since the cereals acted as a supporting crop for the vetch. Strains of nodule bacteria that are formed on the root system of the vetch were fed with nitrogen to the plant of seed oats and spring barley.

The use of mixed crops as green manure has an advantage over monoculture because the number of plants and the density of the vegetative mass per hectare increase. The advantage of mixed crops is that they form vertical layering of crops in the second half of the growing season due to the difference in the growth of the components of the mixtures. Therefore, the cultivation of vetch-grain mixtures for green manure purposes is very important, due to the enrichment of the soil with plant residues and symbiotic nitrogen of the air.
The length of the stem of vetch plants in different variants of the experiment reached 1.1 – 1.2 m, with the exception of sowing vetch in a single-species sowing – 1.3 m.

The number of leaves per plant in mixed crops for plowing into the soil is an important indicator, and it should be taken into account when selecting crops. The authors established the dependence of the number of leaves per 1 vetch plant on the sowing method with oats, barley and lupine ranged from 83.5 to 95.9%. It should also be noted that the leafiness of the legume component in mixtures is usually 2–3% lower than the leafiness of plants in single-species crops. In our studies, this indicator varied from 4 to 16% and decreased as the phases of plant development passed.

The joint growth of two legumes is of great interest, where both cultures, competing with each other, were mutually oppressed. This was clearly manifested on narrow-leaved lupine plants, since on vetch plants they have a creeping leafy stem, which clings to the stems of narrow-leaved lupine.

On the option of co-sowing vetch with oats in the proportion 1:1, the highest productivity of green mass was 65.7 g, which may well compete with the option of sowing vetch in single-species sowing and this method is traditionally used for green manure. Low productivity of green mass of vetch was observed in the variant of co-sowing with narrow-leaved lupine, on which the mass of vetch plants was only 48.6 g, which is 1.5 times lower compared to single-species sowing of vetch. On the variant of the field experiment of the vetch sowing with spring barley, the productivity of the 1st plant of the vetch sowing was at the level of 51.4 – 52.7 g.

Thus, after the conducted studies of the use of vetch in mixed crops for green manure purposes, it is possible to recommend joint sowing 1:1 (through a row) of vetch with oat as an alternative way to single-species sowing of vetch.

Another important feature of mixed sowing of vetch for green manure is the adaptability of legumes and cereals to plant survival, it is determined both by the method of sowing the components, and by the field germination of seeds and the persistence of plants for harvesting, which ultimately determines the density of plants.

In our research, field germination of legumes and cereals in mixed crops was higher for all variants than for single-species crops. Field germination of spring barley in mixed sowing 1 + 1 and in single-species sowing made 100%. Comparing the field germination capacity of the vetch sowing in its pure form with the variants in mixed crops, we can conclude that this indicator is at the same level for them. Thus, in the mixed herbage, the field germination of both legumes and cereals decreased in proportion to the increase in the share of another component.

The survival rate of plants of leguminous and cereal components during their cultivation in single-species crops in the period from germination to harvest remained high and amounted to 98.4% in sowing vetch, 95.1% in seed oats, 94.4% in spring barley, and 86.0% in narrow-leaved lupine. However, in mixed crops of the vetch with spring barley, as the share of the legume component in the agroecosystem increased and the share of the supporting crop, spring barley, decreased, the survival rate of the vetch gradually decreased and amounted to 90.2 – 93.4%, in spring barley – 70.1–95.7%. The highest value for this indicator was on the variant of mixed sowing of vetch with spring barley 1 + 1, as well as in single-species sowing of spring barley. With a similar proportion of vetch, the safety of plants in seed oats, on the contrary, increased to 3%, which indicates that both components of the mixture were correctly selected and they grew without competing with each other. Therefore, it is very important to choose the right combination of legume and cereal components so that mixed crops do not oppress each other and do not lodge until harvesting, which prevents plowing of these crops as green manure.

It was found that in the conducted studies of mixed sowing of vetch with cereals and legumes, the maximum planting density was observed in mixed crops of vetch with sowing oats; the method of sowing did not affect this indicator. The density of standing of vetch sowing plants in mixed crops for the period of harvest ranged from 261.9 pcs to 488.4 pcs, depending on the sowing method.

Thus, the studies showed that the sowing method of sowing did not affect the field germination rate of vetch, the preservation of vetch plants was better in the variant of mixed sowing of vetch with spring barley 1 + 1, and the safety of cereal plants – in the variant with spring barley. The density of the vetch in single-species crops exceeded the indicators of mixed sowing.
4. Conclusion

*Vicia sativa L.* is an economical fertilizer that allows enriching the soil quickly with nutrients and destroying weeds in the arable field. It is necessary to water the plant periodically for full growth.

The conducted studies of the use of vetch in mixed crops for green manure purposes showed that it is possible to recommend joint sowing 1:1 (through a row) vetch with oats as an alternative way to single-species sowing vetch.

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