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Productivity of spring vetch plants in single and mixed crops depending on meteorological conditions

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ABSTRACT

Spring vetch in single and mixed crops forms a green mass in various meteorological conditions and is a member of the green conveyor. It is widely used in intermediate crops (mowing, repeated, stubble). Due to the fact that pure crops of spring vetch are lodged, oats, spring wheat, barley, etc. are used as support crops. Most of the zoned varieties of the universal grain type have medium-sized seeds and are distinguished by high grain and green mass productivity. In variety testing of spring vetch of three varieties belonging to different groups by seed size, it is of interest to use them. Small-seed varieties of spring vetch are universal, while large-seed grain forage varieties. The search for varieties that meet high requirements for tolerance, field germination and survival in joint crops is an urgent task.

Key words: Spring vetch, Germination, Survival, Productivity, Yield.
Article type: Research Article.

INTRODUCTION

According to many authors, mixed crops contribute to a more economical, less costly use of mineral fertilizers and herbicides for weed control. Thus, the production of grain cultures and legumes allows to reduce the application of nitrogen fertilizers for the main crops of crop rotation by 15 - 20%. After their harvesting, 2.3 - 6.7 ton $ha^{-1}$of root and crop residues remain, containing nitrogen, potassium, and phosphorus, which are easily available for subsequent crops. For the production of 1 ton of hay, spring vetch consumes about 6 kg of P_2O_5, 15 - 17 kg of K_2O, a lot of potassium and magnesium from soil. This crop grows well on various soils, but best of all on cohesive soils, characterized by high water-holding capacity, with a soil solution pH of 5-6.5. Meteorological conditions are the main indicator affecting the productivity of plants of the legume-cereal mixture, germination and survival of plants for harvesting. Critical periods for the growth and development of vetch in single and mixed crops are the following: seedling, flowering and grain filling. An increased temperature regime in combination with a lack of moisture supply in the soil entails the plant survival rate and productivity decrease in each period, and the displacement of vetch plants by a cereal component in mixed crops and a general decrease in grain yield. At present, the compatibility of sown varieties for grain fodder and green mass of cereals (oats, spring barley) and legumes remains an urgent task. The selection of new varieties of cereals and leguminous crops is aimed primarily at grain yield increase in order to obtain balanced feed in protein and essential amino acids. The creation of sustainable agrocenoses allows to increase the balanced fodder base for farm animals. Also, the creation of tolerant vetch-cereal mixtures makes it possible to sustainably engage in seed production of leguminous crops in the Non-Black Earth Zone of the Russian Federation.

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There are several reports about plant diversity around the world (Ameri Siahouei *et al.* 2020; Vladimirovna *et al.* 2020; Abolhasani *et al.* 2021; Porusia & Septiyana 2021) When selecting support crops and varieties for grain fodder, it is necessary to take into account the onset of mowing ripeness of both components. Mixed seeding facilitates mechanized harvesting and provides seeds with high sowing qualities. When selecting components for mixed agrophytocenosis, it is necessary to combine the number of plants of each component per area unit to obtain an optimal leaf surface. Thickening of crops creates additional competition for nutrients, moisture and light and negatively affects the overall productivity of the crop.

During the search of an optimal component for mixed sowing and a high yield of spring vetch seeds in the mixture, we studied vetch varieties of spring and cereal crops in single and mixed crops with cereals, providing high survival and productivity of plants for harvesting.

When analyzing the experimental data and testing the varieties of spring vetch, they were divided into 3 groups by the weight of 1000 seeds: small-seed up to 60 g (the variety Lyudmila), medium-sized seeds 61 - 70 g (the variety Nemchinovskaya Yubileynaya) and large seeds over 70 g (the variety Ugolek). Comparison of the productivity level of spring vetch cultivars in single and mixed crops, as well as the study of ecological plasticity parameters, makes it possible to analyze the direction of selection not only for manufacturability, but also the adaptability of cultivars to the conditions of the Non-Chernozem zone of the Russian Federation.

MATERIALS AND METHODS

The work on the creation of the spring vetch variety adapted to the zonal conditions was carried out by the methods of traditional breeding according to the complete scheme of the breeding process. Phenological observations, measurements and counts were carried out according to the Methodology of the State Commission for Variety Testing of Agricultural Crops (Part 2, 1989). The research was carried out in 2005 - 2010. The research material was the breeding varieties of the Federal Research Center "Nemchinovka": spring vetch varieties Lyudmila, Nemchinovskaya jubileynaya, Ugolek, Raushan barley, and Trump oats. The task of the research included the study of field germination, survival, productivity of spring vetch plants in single and mixed crops with cereals. The experiment was carried out in the selection crop rotation No. 1 of the Federal Research Center "Nemchinovka". The soil of the experimental site is sod-podzolic medium loamy. The content of the main predecessors in the arable (0 - 20 cm) layer after harvesting was the following: humus 1.5 - 1.7%, P_2O_5 and K_2O (0.2 HCl according to Kirsanov) - 160 - 300 and 130 - 220 mg kg^{-1}, respectively, pH KCl - 5.3 - 6.7, Ng (according to Kappen-Gilkovits) - 0.94 - 2.62 mg-eq/100 g. The soil is well cultivated for sowing, mineral fertilizers NPK were applied at the dose of 48 kg per 1 hectare. The plot area was 10 m^2 in 4-fold replication. Sowing was carried out at the end of April with a portioned device of the SSK - 6 - 10 seeder. The seeding rate of vetch is 1.2 million of germinating grains per hectare, 3.0 million of germinating grains of oats and barley. The soil cultivation system is generally accepted for the region. Harvesting was carried out at full maturity of the plants using "Xege-125" selection harvester.

Over the years of research, meteorological conditions were contrasting both in temperature regime and in the amount of precipitation during the growing season. Thus, the meteorological conditions of 2005 were characterized by a temperature regime close to the average annual value with the deviation of ± 2.5 ºC during the entire growing season, except of the third decade of May, where the temperature rise was 4.4 ºC. The amount of precipitation during the growing season was also unevenly distributed. Thus, in the first ten days of June and August, the amount of precipitation was 3 and 4.2 mm, with an average annual of 23.0 and 27.4 mm, respectively. The hydrothermal coefficient for May and June amounted to 1.91 and 2.56, which is 0.52 and 1.06 more than the average long-term values. The weather conditions in August were characterized by heavy rainfall, which made harvesting difficult. In 2006, the temperature regime was at the level of average long-term values with small fluctuations, which did not affect the passage of phenological phases of plant development. In the third decade of May, the amount of precipitation was 34.8 with a norm of 19.7 mm, which partly compensated for the reserves of productive moisture in the soil. The amount of precipitation in June was slightly more than the average annual values and amounted to 80.4 mm. July 2006 was dry with the amount of precipitation making 1/3 of the average annual values, with the HTI indicator of 0.48 at the norm of 1.58. Lack of moisture turned out to be critical for the flowering phases and for the formation of beans and grain filling. The growing season of 2007 was dry. May and June droughts strongly influenced the germination and initial growth and development of plants. HTI for May, June and July amounted to 0.86, 0.33 and 0.95, which makes 40-70% of the hydrothermal coefficient. The

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temperature regime exceeded the average long-term values throughout the growing season by 2.5-5ºC, which, together with the lack of moisture, significantly reduced the passage of phenological periods by plants. By the beginning of August, the legume plants had fully formed their grain and were fully ready for harvest. The temperature regime in 2008 was close to the average long-term values during all periods of plant development, except for the distribution of precipitation during the growing season. So, in the first and second ten days of May, the lack of precipitation was 40% of the average long-term values, and it reflected on the amicability of seedlings. The HTI for May was 1.99, while the norm was 1.39. The second decade of July and August was characterized by warm weather with heavy rainfalls and sharp gusts of wind, which caused lodging of grain legumes. In the third decade of July, the amount of precipitation was 8.8 with the norm of 28.8 mm, but this did not affect the supply of productive moisture in soil.

The drought in the first and second decades of May 2009 affected seedling and initial plant growth. The amount of precipitation in decades was 1.5 and 13.8 mm with mean annual values of 14.7 and 18.0 mm, respectively. In the third decade, 31.1 mm of precipitation fell, which is 11.4 mm more than the average long-term value with HTI value of 1.09. In the second and the third ten days of June and July, there were no periods with low precipitation. HTI for June amounted to 0.87, which is 0.63 less than the average monthly multi-year indicator. In the first decade of July, 80.9 mm of precipitation fell at the rate of 29.8, which is 2.7 times more than the decade rate. Subsequently, the amount of precipitation in the second and third ten days of July was 11.5 and 8.3 mm, with a norm of 27.2 m 28.8 mm. The temperature regime in 2010 was characterized by increased air temperature throughout the growing season, with the exception of the first and second ten days of June, where the temperature background corresponded to the average long-term values. The air temperature exceeded the average annual values by 5 - 8 ºC. This was especially negatively reflected in the period of flowering, formation and filling of grain. The actual amount of precipitation in the third decade of June was 0.3 with the norm of 29.8 mm. The level of moisture supply (HTI) in June was 1.18, while the norm was 1.5. In the first decade of July, there was no precipitation and the third decade with 70% of precipitation as compared to the average annual values. The HTI in July was 0.5 at the rate of 1.58. The HTI for August was 1.02, while the norm was 1.62.

RESULTS

An important indicator of phytocenotic relationships in single and mixed crops is the field germination of seeds and plant survival. When assessing the adaptability and stability of the plant survival trait, i.e., the combination of high adaptive ability with plant stability is characteristic of the variety Nemchinovskaya Yubileynaya in single and mixed crops. Many factors influence the yield amount per area unit. An objective picture of the crop formation can be obtained on the basis of its structure element analysis, which include the plant density, the number of beans and the mass of seeds per plant. Tables 1-2 present the experimental data on field germination and plant survival for harvesting.

Table 1. Field germination of spring vetch varieties in pure and mixed crops (%). (2005-2010).

Year / Variety	2005	2006	2007	2008	2009	2010	Average
single-species sowing							
Ludmila	85	90	77	65	76	86	80
Nemchinovskaya jubileynaya	85	87	74	69	85	85	81
Ugolek	86	93	77	61	80	81	80
mixed with oats							
Ludmila	89	86	69	77	81	89	82
Nemchinovskaya jubileynaya	81	89	67	83	75	81	80
Ugolek	88	81	59	77	84	85	79
mixed with barley							
Ludmila	89	88	51	60	84	84	76
Nemchinovskaya jubileynaya	82	88	72	65	85	81	79
Ugolek	87	83	77	69	85	86	81
HCP_{05}	3.4						

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As was shown in Table 1, the field germination of vetch plants by varieties in single and mixed crops varies in a small range: from 76% - the variety Lyudmila mixed with Raushan barley to 82% mixed with Trump oats.

Table 2. Survival of plants of spring vetch varieties in pure and mixed crops (%). (2005 - 2010).

Year / Variety	2005	2006	2007	2008	2009	2010	Average
single-species sowing							
Ludmila	63.3	71.5	61.1	71.3	94.1	88.3	74.9
Nemchinovskaya jubileynaya	67.6	90.1	78.5	92.4	90.6	75.3	82.4
Ugolek	71.6	96.1	72.7	90.1	91.6	79.6	83.6
mixed with oats							
Ludmila	60.6	69.6	67.7	67.9	89.9	70.2	71.0
Nemchinovskaya jubileynaya	62.0	88.0	58.6	75.1	85.4	82.1	75.2
Ugolek	60.7	75.9	69.2	69.2	71.6	84.9	72.0
mixed with barley							
Ludmila	67.9	77.0	56.1	78.1	90.4	69.9	73.2
Nemchinovskaya jubileynaya	62.6	69.6	86.5	64.8	89.1	76.3	74.8
Ugolek	80.0	63.8	75.7	70.4	81.7	73.9	74.3
HCP_{05}	4.1						

The data of the Table 2 indicate a high survival rate of plants for harvesting, both in single and mixed crops. The data of single-species crops indicate that the medium and large-seed varieties of spring vetch Nemchinovskaya Yubileynaya and Ugolek exceed the small-seed variety Lyudmila by 10% on average. The survival rates of varieties to harvesting make 82.4% and 83.6%. The excess is also observed in mixed crops with Trump oats and Raushan barley. Thus, in the mixed sowing with oats, the excess is 1% for the Ugolek variety and 4.2% for the Nemchinovskaya jubilee variety. In mixed sowing with barley, the excess is 1.1% with the Ugolek variety and 1.6%. One of the main indicators of agrophytocenosis effectiveness is seed productivity and yield. To determine the seed productivity of cenoses on the experimental plots, plants were selected for laboratory analysis. In our experiments, it was determined for pure and mixed crops and its results after the years of research are presented in Table 3.

Table 3. Weight of seeds per plant among spring vetch varieties in pure and mixed crops during 2005 - 2010 (g).

Year / Variety	2005	2006	2007	2008	2009	2010	Average
single-species sowing							
Ludmila, st	4.7	2,4	0.6	4.5	4.2	1.2	2.9
Nemchinovskaya jubileynaya	5.0	2,5	0.61	4.1	4.6	1.4	3.0
Ugolek	4.5	2,5	0.57	3.8	4.0	0.9	2.7
mixed with oats							
Ludmila, st	4.3	2,7	0.9	3.9	4.7	1.5	3.0
Nemchinovskaya jubileynaya	5.1	4,0	0.95	3.5	5.0	1.6	3.4
Ugolek	4.2	2,8	1.0	3.8	4.6	1.3	3.0
mixed with barley							
Ludmila, st	4.7	2,4	1.5	4.1	3.9	1.6	3.0
Nemchinovskaya jubileynaya	4.3	2,8	1.9	4.5	4.9	2.0	3.4
Ugolek	4.5	3,3	2.1	4.5	5.2	1.8	3.6

When analyzing the data in Table 3, it can be seen that during cultivation in mixtures for seeds, the variety Nemchinovskaya Yubileynaya with medium-large seeds showed the highest productivity in single-species and mixed crops - 3.0 and 3.4 g, respectively, and the large-seed variety Ugolek made 3.6 g only in mixed crops with the barley Raushan.

The large-seed variety of spring vetch Ugolek surpasses the small-seed variety Lyudmila and the medium-seed variety Nemchinovskaya Yubileynaya in terms of grain yield in a mixture and pure vetch, but it is inferior in yield of hay. The large-seed vetch does not affect the early maturity and branching of plants. Taking into account the green mass of plants (during the phase of bean formation), large-seed varieties are distinguished by the content of

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beans. The number of beans increases from the small-seed group (Lyudmila) - 28.4% to the large-seed group (Ugolek) - 30.6%. Along with this, branching is increased from 1.21 in the Lyudmila variety to 1.5 - Ugolek.

Testing results of spring vetch new varieties, on average for 2005- 2010.

Variety	Productivity, c/ha on average						Productivity of oat grain from a mixture, kg ha^{-1}	Weight of 1000 seeds (g)	Vegetation period, days	Protein content in grain (%)	Branchiness	Weight of beans in green mass (%)
	grain		Green weight		hay							
	mixture	vetch	mixture	vetch	mixture	vetch						
Ludmila	35.1	15.0	301.2	136.6	84.3	38.7	20.1	53.9	92	26.8	1.21	28.4
Nemchinovskaya jubileynaya	34.6	15.8	320.4	134.1	90.7	38.0	18.8	68.0	94	27.1	1.33	27.8
Ugolek	38.3	16.9	310.4	137.5	83.2	40.7	21.4	71.6	94	30.3	1.5	30.6

CONCLUSION

Considering the results of spring vetch testing varieties, entered in the state register of breeding achievements, it can be concluded that varieties can be divided into 3 groups by the weight of 1000 seeds: the first group includes the varieties with the weight of 1000 seeds, small-seed up to 60 g - grain-cutting direction, medium-large 60 - 70 g - universal and large-seed, with the mass of 1000 seeds over 70 g, late-ripening mowing varieties for mixed sowing with oats and barley in the southern regions of the Russian Federation. High field germination and survival rate of vetch plants for harvesting is observed in the variants with the least competition for nutrients, light and moisture with cereals. This is achieved by selecting the seeding rate for each component of the mixed sowing, as well as the tolerance of the varieties. Large-seed varieties exceed small-seed varieties in terms of the total yield of grain mixture and vetch seeds due to the greater mass of 1000 seeds. In crops with cereals, large-seed varieties have better branching of vetch plants, and also exceed small-seed ones in the number of beans per plant, which provides a high potential of green mass and increases the yield of metabolic energy and protein per area unit. Getting vetch grain with a high protein content in mixed crops with oats or barley is of great production value, no less than the cultivation of peas or lupine. Mowing varieties include early maturing, fast-growing small-seed varieties of spring vetch for intermediate crops: mowing, stubble and repeated.

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