Influence of methods and norms of sowing soybean seeds of the Northern ecotype on yield

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Abstract. The article presents the results of studying the optimal norms and methods of sowing a new variety of soybeans of the northern ecotype of the Memory of Fadeev for 2016-2018 at the experimental site of the Chuvash Research Agricultural Institute-a branch of the Federal State Budgetary Institution “Federal Agricultural Research Center of the North-East named after N V Rudnitsky” in the southern part of the Volga-Vyatka region of Russia. It is established that in order to obtain high yields of soybean seeds of the northern ecotype in the conditions of the Chuvash Republic, the ultra-ripe variety of soy in Memory of Fadeev should be sown in a wide-row way at a rate of 600 thousand germinating seeds per 1 ha. It is revealed that to obtain a higher attachment of the lower bean, narrow-row sowing is recommended – the height of the attachment increases to 17.3 cm. Wide-row sowing increases the number of beans, the number and weight of seeds per plant, as well as the weight of 1000 seeds, which leads to an additional yield of up to 6.8 c/ha. According to the data obtained, an agroecological passport has been developed for a new Chuvash soybean variety of the northern ecotype of the Fadeev Memory variety, zoned in 2019.

1. Introduction
Soy is a short-day crop that has a long maturation period and requires a large amount of active temperatures [1, 2]. At the beginning of the twentieth century, it was believed that the Northern border of soybean cultivation runs along the 53rd parallel of northern latitude [3]. The process of acclimatization of soybeans to the northern regions of Russia has accelerated thanks to the purposeful selection work of Chuvash breeders. Chuvashia is located between 54 and 56 of northern latitude, and it is not a soy producing Republic, but the prospects for the production of soybeans due to the appearance of varieties of the Northern ecotype are quite available [4]. For the development of soy requires the sum of temperatures from 2000 to 3000 °C, with the number of frost-free days of at least 120-150, with an average daily temperature of at least 15 °C [5]. One of the new promising Chuvash soybean varieties of the northern ecotype is the Fadeev Memory variety. According to the length of the growing season, according to the international and industrial classification, the variety is a carrier of the genes of the precocious group. The vegetation period of plant development from germination to economic maturity in the conditions of the central part of Russia is from 90-100 days when the total active temperatures above 10 °C are from 1800 to 2100 °C.

To realize genetic potential yields and maximize the yield of high-quality seeds, it is necessary to investigate cultivation methods and develop varietal technologies that optimize the seed productivity of crops [6, 7]. The potential of the variety is more fully disclosed in the conditions of sufficient provision of plants with factors of their vital activity. Creating favorable conditions for the growth and
development of plants due to agrotechnical techniques applied to agro-climatic conditions of cultivation is the key to realizing the genetic potential of the variety. The main agricultural techniques include the seeding rate and the method of seeding. These factors have a significant impact on the formation of the bush and the quantitative indicators of soybean yield [8-13].

It is known that soy, as a light-loving crop, reacts to the way the plants are placed. Yield formation for soybeans starts with the planting of the seed in the ground and ends when the grain is harvested. When growing soybeans in production conditions, the most common methods of sowing are wide-row (45, 60 or 70 cm) and ordinary (15 cm). Studies have established that there is a specificity in the reactions of different soybean varieties to the methods of sowing [14]. Many producers use a 30-inch row width since it is well-suited for other row crops; however, narrower row soybeans are increasingly popular. Rows narrower than 30 inches have several advantages. It is established that, narrower rows allow the soybean crop to provide an early canopy cover, increase weed suppression, improve light interception, and increase the probability of greater yields. Soybeans have a great capacity to adjust seeds per pod and pods per plant to compensate for differences in plant stand. As plant population decreases, seeds per pod and pods per plant increase, helping to offset yield losses from lower plant stands. Soybeans in drier environments usually benefit from a lower planting rate, while late plantings require increased seeding rates to compensate for the lack of canopy growth [15, 16].

At the serene latitude of 54°, studies were conducted on northern soybean varieties such as Kasatka, Svetlyaya, Mageva and Okskaya to clarify the timing, methods of sowing and seeding rates that ensure the optimal density of coenosisis in soybean crops and ultimately its maximum productivity [17]. Earlier, in 2015-2017, two methods of sowing soybean varieties of the northern ecotype of Fadeev Memory were studied – wide-row with a row spacing of 50 cm and narrow-row with a row spacing of 15 cm at different seeding rates – from 350 to 650 thousand germinating seeds per hectare. According to the results, it was found that the production density of soybeans depends on the level of hydrothermal parameters. With the improvement of the water regime, an increase in the density of crops contributes to the formation of the greatest yield. The lowest yield results (19.2; 18.3 c/ha) were obtained in 2015-2016 in the variant with the seeding rate of 650 thousand seeds per ha, regardless of the seeding methods. And in the cold 2017, the smallest harvest was collected from an area with a seeding rate of 550 thousand seeds per ha (17.5 c/ha). Wide-row crops with a row spacing of 50 cm on average for three years provided seed collection of 26.8 c/ha, which is 2.3 c/ha higher than narrow-row crops with a row spacing of 15 cm [18]. Since 2016, additional variants have been added to the scheme of experience, the three-year results for which are presented in this article.

The relevance of this work lies in the individual determination for a particular soybean variety of the northern ecotype of the optimal parameters of the stem density and methods of placement per unit area for cultivation at 56 degrees north latitude. To identify the potential of the Fadeev Memory variety, various agricultural practices were studied, such as seeding methods (ordinary and wide-row) and seed seeding rates.

The purpose of the research is to determine the optimal norms and method of sowing soybean seeds of the northern ecotype of the new variety of Memory of Fadeev for the development of an agroecological passport.

2. Materials and methods
The territory of the Chuvash research Institute is located in the second agro-climatic sub district of the Republic, so the cool moderately humid sub district of the Volga oaks in the southern part of the Volga-Vyatka region of the Nonchernozem zone of the Russian Federation.

The soil on the site is gray forest, heavy loam, slightly washed with a humus content of 4.9. Indicators of the availability of the arable soil layer for mobile phosphorus and exchange potassium are high, and the degree of acidity is neutral. According to their agrophysical and agrochemical properties, the soils of the experimental site are favorable for the cultivation of soybeans.
According to its geographical location, the territory of the Chuvash research Institute is located in the zone of continental climate, which is characterized by warm, sometimes hot summers and moderately cold, long, snowy winters. The prevailing winds are South-westerly.

The climate of the area is continental. Summer is dry and hot, winter is cold. The transition from winter to summer is abrupt. The maximum temperature is +23.6 °C, the minimum –13.2 °C. The average Annual air temperature is +1.1 °C. The Average annual precipitation is 350 mm. According to the intra-regional agro-climatic division, the branch's soil lands are included in the area of favorable humidification. Precipitation is uneven: more precipitation occurs during the warm period [19].

As part of the research on this topic, a multi-factor field experience was laid. The object of the study was soybean crops of the northern ecotype of the Fadeev Memory variety, elite reproductions. Soybean seeds were sown in two ways, the wide-row method (W) with seeding numbers of 400, 500, 600 and the ordinary method (Y) with a row spacing of 15 cm with seeding rates of 500 and 600. The repetition is 3-fold. The plot area is 10 m². Sowing was carried out manually. The location of the plots is systematic with an offset of 1 option. The scheme of the experiment involved the study of the following options:

1. W – 400 thousand germinating seeds per 1 ha-standard;
2. W – 500 thousand germinating seeds per 1 ha;
3. W – 600 thousand germinating seeds per 1 ha;
4. Y – 500 thousand germinating seeds per 1 ha;
5. Y – 600 thousand germinating seeds per 1 ha.

The agricultural technology of the soybean crops corresponded to the production conditions developed on the basis of local agronomic recommendations for this area. After harvesting the predecessor-winter wheat and regrowth of a significant number of weeds, stubble husking was carried out at the experimental site by disking to a depth of 6-8 cm, then plowing was carried out to a depth of 25-27 cm. Since the main requirement of spring processing for soybeans is to ensure a fine-crumpled addition of the seed layer and the creation of a seedbed to a depth of 6-8 cm of seed embedding. The need to place seeds in a moist layer dictates the importance of maintaining sufficient moisture reserves in the seedbed. To achieve this goal, 1-2 cultivations are carried out on the plowed swell for sowing soybeans in early spring as the weeds grow back.

When conducting field research, modern scientific methods of planning and conducting field experiments were used. Phenological observations, taking into account the morphometric parameters of plants and elements of productivity were carried out on permanent sites laid in two non-adjacent repetitions. Accounting, analysis and experimental observations were carried out according to the generally accepted methods of experimental work. The reliability of the results of research on the growth and development of plants is confirmed by the use of modern methods. Statistical processing of experimental data was carried out by the method of variance analysis [20] using computer programs Microsoft Excel 2003, CXStat, Statistica 10.0. The experiment was accompanied by the following accompanying observations and studies: selection of soil samples according to GOST 28168-89 [21]. Soils; biometric analysis [22]. Soybean harvesting was carried out manually, the sheaves were threshed on a stationary thresher. Seed quality was determined according to the current methods: germination energy and laboratory germination—according to GOST 12038-84 [23], weight of 1000 seeds according to GOST 12042-80 [24].

The Fadeev Memory variety is ultra-ripe, highly productive, and resistant to lodging, cracking of beans and shedding of seeds, plastic to long-day conditions. The plant is of medium height – 65-85 cm, the bush is erect, semi-compressed, determinant, sparsely branched, the pubescence is red, and the flowers are purple. The main stem has 15-16 productive nodes. The attachment height of the lower bean is 12-14 cm. The weight of 1000 seeds is 170 g on average. With a high potential of seed yield, the average yield is 2.66 t/ha, the maximum – 3.23 t/ha (Starosindrovsky GSU) under irrigation – 4.27 t/ha. Drought tolerance is above average. Suitable for direct harvesting. The protein content in the seeds is 37-41%, fat – 18-20%.

The structure of sowing and productivity of soybean plants in northern latitudes are formed depending on the level of heat and moisture supply during the growing season. During the study period, the
hydrothermal conditions varied greatly by year and phase of plant growth and development [25]. In 2016 and 2018 the growth and development of field crops took place under conditions of lack of moisture against the background of a high temperature during the entire growing season. Spring grain tillering was very weak. Selyaninov hydrothermal coefficient in 2016 amounted to 0.58, and in 2018 – 0.68. The sum of active temperatures of the growing season of spring soft wheat in 2016 amounted to 2402 °C, and in 2018 – 2250 °C. In 2017, the growth and development of agricultural crops took place under conditions of excess moisture against the background of cold temperature at the beginning of the growing season (May, June) and close to the average multiyear norm during the rest of the growing season. Selyaninov hydrothermal coefficient amounted to 1.49. The sum of the active temperatures of the spring wheat growing season was 1825 °C [26].

3. Results and discussion

The main feature of the soybean variety is the height of the attachment of the lower beans. This feature is the main technological and economic valuable feature for cleaning. Knowing this feature allows you to minimize crop losses. Research in 2016-2018 on the influence of norms and methods of sowing Northern ecotype soybeans on the elements of the crop structure showed that the height of attachment of the lower bean in narrow-row sowing is higher than in wide-row sowing (figure 1). So if in the control version, the height of the lower bean attachment leaves 14 cm, then in the versions with narrow-row seeding with seeding rates of 500 – 17.3 cm, which is 2.9 cm higher, respectively, 20.1%.

![Figure 1. Influence of the norm and method of seeding on the attachment height of the lower bean on average for 2016-2018, cm.](image-url)

The number of beans per plant shows the productivity of the crop and depends on the agrotechnical conditions of cultivation, soil and climate conditions and biological characteristics of the variety. In the control variant, with wide-row seeding with a seeding rate of 400, the number of beans per plant for three years of research averaged 31 PCs (table 1). In broad-row seeding with a seeding rate of 500-26 PCs, 600-24 PCs. This is 5 and 7 beans less than the control (16.1 and 22.6%, respectively). In a narrow-row seeding with a seeding rate of 500 is significantly lower, compared to the control variant by 10 PCs (32.2%).

The weight of seeds from a plant is a complex sign, which depends most significantly on weather conditions. In the control variant, with a wide-row method of sowing with a seeding rate of 400, the number of seeds per plant is significantly higher. When seeding with a wide-row seeding method with a seeding rate of 500 and 600, the number of seeds per plant averaged 55 and 48 pieces. This is 7 and 14 pieces less than the control variant, respectively by 14 and 22.6%. With a narrow-row method of seeding with seeding rates of 500 and 600-20 and 26 seeds less than in the control version, respectively, 32.3 and 41.9%.
Table 1. Influence of the norm and method of seeding on the number and weight of beans per plant on average for 2016-2018.

| Options                                      | Number of beans per plant, PCs | Number of seeds per plant, PCs | Weight of seeds per plant, g | Weight of 1000 seeds, g |
|----------------------------------------------|--------------------------------|--------------------------------|-----------------------------|-------------------------|
| W-400 thousand germinating seeds per 1 ha – standard | 31                             | 62                             | 9.6                         | 156                     |
| W-500 thousand germinating seeds per 1 ha    | 26                             | 55                             | 8.6                         | 156                     |
| W-600 thousand germinating seeds per 1 ha    | 24                             | 48                             | 7.4                         | 155                     |
| Y-500 thousand germinating seeds per 1 ha    | 21                             | 42                             | 6.3                         | 151                     |
| Y-600 thousand germinating seeds per 1 ha    | 28                             | 34                             | 5.0                         | 146                     |
| NSR0.5                                       | 2.5                            | 12                             | 1.8                         | 4.2                     |

The most important economically valuable feature is seed productivity, which is determined by the weight of seeds from a single plant. The weight of seeds in the experiment on control from one plant is on average higher than in other variants. The lowest indicators are observed at the seeding rate of 600 thousand germinated seeds per 1 ha: with the narrow-row method, 5.0 g, which is 4.6 g (47.9%) lower than the control, and with the wide – row method, 7.4, which is 2.2 g (23%) lower than the control.

The mass of 1000 seeds is determined to characterize the fullness and size of the seeds. It was found that with a narrow-row method of sowing with a seeding rate of 500 and 600, the average weight of 1000 seeds relative to the control decreased by 4 (3.2%) and 10 g (6.4%), respectively. With a wide-row method of seeding, regardless of the seeding rate, the indicator is at the control level. From the analysis of the data shown in figure 2, it can be seen that with ordinary sowing, lower yields are achieved on average for 2016-2019 in comparison with wide-row sowing.

![Figure 2](image)

**Figure 2.** Influence of the norm and method of sowing seeds on the average yield for 2016-2018, c/ha.

In the variant with the seeding rate of 600 seeds, the maximum yield was 41.4 c/ha. The Excess to control was 6.8 c/ha (19.7%). With narrow-row seeding, the yield reduction was: with a seeding rate of 500 seeds to 27.1, which is lower than the control by 7.5 c/ha (21.7%); with a seeding rate of 600 seeds to 26.5 c/ha, which is lower than the control by 8.1 c/ha (23.4%).

4. Conclusion

Depending on the method of seeding, there are noticeable differences in the options:
- with narrow-row seeding, the height of the lower bean attachment increases;
- with wide-row seeding, an increase in the seeding rate increases the number of beans, the number and weight of seeds per plant, as well as the weight of 1000 seeds, which leads to an increase in yield by 6.8 c/ha (19.7%);

According to the research results, it is recommended to use a wide-row seeding with a seeding rate of 500-600 thousand germinating seeds per hectare for the Fadeev Memory variety.

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