Parameters of the optimal plant density of winter rape for successful overwintering in the Non-Chernozem zone

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Abstract. To obtain high yields of winter rapeseed seeds in the Non-Chernozem zone, it is necessary to provide conditions for good wintering. The studies were carried out in order to establish the optimal plant density of the zoned variety Severyanin. It was found that when sowing in rows with a row spacing of 25 cm, winter rape plants develop better, form a rosette of leaves with a lower location of the growing point, form a smaller amount of aboveground mass per unit of roots, which increases the safety of plants in winter by 2.5-4.3%. The study of the dynamics of the plant density of winter rapeseed at different seeding rates showed that during the growing season, self-thinning of cenosis occurs. On average, over the years of research, plants overwintered better in variants with a lower stand density. With an increase in the seeding rate, the completeness of seedlings, the safety of plants in the autumn period, overwintering and the safety of plants in the year of harvesting for seeds decreased. The most optimal conditions for the preservation of plants for harvesting are provided at low seeding rates: with a row sowing with a row spacing of 25 cm with a seeding rate of 0.7-1.0 million pieces / ha, with an inter-row sowing (row spacing of 25 cm) - 0.5 million pcs / ha of germinating seeds: With the over-row sowing, the safety of plants for harvesting was higher than with the row method by 9-25%.

Keywords: winter rape, variety, seeding rate.

1. Introduction

In the Central Region of the Non-Black Earth Zone of Russia, great importance is attached to increasing the production of oilseeds. This will create a stable raw material base for the production of edible vegetable oil, high-protein feed and feed additives for livestock and poultry [1,2].

Winter rape, in comparison with spring rape, provides 1.5 times more oilseeds collection per unit area while reducing the cost of their production. This excludes the use of chemical remedies in the fight against the cruciferous flea. In the southern and central regions of the forest zone, winter rape can be cultivated in a busy fallow, harvest in July before grain crops ripen and place winter crops after harvest [3,4,5]. This is the earliest marginal oilseed crop, opening the processing season at oil refineries [6].

Despite these advantages, winter rape is a new crop for the conditions of the center of the forest zone. The main reason for this was the lack of winter-hardy varieties. The creation of new varieties of winter rapeseed, characterized by increased winter hardiness, made it possible to significantly expand the area of cultivation of the crop [7]. The two-zero variety of winter rapeseed Severyanin, created at the Federal Research Center “VIK named after V.R. Williams” - the first approved for use in the Central region of
the country. The creation of the variety made it possible to significantly expand the area of cultivation of the crop. The variety is suitable for the production of vegetable oil for food purposes and high-protein feed for livestock and poultry farming. Ecologically plastic, characterized by uniform flowering and ripening, increased resistance to lodging [8].

The expansion of rapeseed areas in the region is largely determined by the availability of quality seeds and the organization of the seed production system. Therefore, research on the development of technology for the production of high-quality seeds of the Severyanin variety is relevant and important for production. For successful overwintering, winter rape plants must form a well-developed rosette of leaves and a root system with the necessary supply of nutrients.

Sowing is one of the main elements of the technology. The density of plants is the most important condition that determines the degree of supply of plants with moisture, light, mineral nutrition and forms their productivity [9]. The number of productive stems, pods, the weight of 1000 seeds varies greatly under the influence of the seeding rate and the row spacing.

In thickened crops, plants stretch out from autumn and bring the growth point to a considerable height from the soil surface, while the root system is poorly formed. It was also noted that with an increase in the seeding rate, the amount of sugar in the leaves decreases, the amount of starch in the leaves and roots increases, which indicates a decrease in the winter hardiness of plants. Overestimated seeding rates lead to the development of weakened plants, a decrease in winter hardiness, productivity and quality of the harvest of rapeseed and rape [10].

Seeding rates that are too high tend to stretch out the central shoot. In those areas where there is a high risk of freezing, it is recommended to focus on lower seeding rates, which contribute to better development of regeneration organs with a shorter stem length [11,12].

Too much density during the growing season often leads to lodging of plants. As a result, delayed flowering and unripe seeds are observed. They not only degrade quality, but also cause crop loss. In addition, the high density of crops creates ideal conditions for the development of fungal diseases. On the other hand, in sparse crops, the risk of weeds contamination increases [13].

Seeding rates are chosen depending on the sowing time and on the varietal type (free-flowering varieties or hybrids). According to German authors, the sowing rate of free-flowering varieties is 50 ... 60 germinating seeds / m² with early sowing, a high level of farming culture, pickling and inlaying. With later sowing and worse conditions, the seeding rate should be 80 ... 100 viable seeds / m² [14]. In the North Caucasus, according to V. K Dridiger and E. Yu. Guriev (2000), the highest seed yield was at a plant density of 80–120 pcs / m² in the germination phase [15]. In the Southern Federal District of the Russian Federation after overwintering, the recommended stand density of winter rape is 50-60 pcs / m² [16]. According to Ya. E. Pilyuk (2007), the density of standing of plants before leaving for winter in Belarus should be 60-80 pieces / m²[17].

2. Methods of the research
The sowing was carried out by the ST7 selection seeder in an ordinary way with the rates of 0.7; 1.0; 1.5; 2 million germinating seeds / ha with a row spacing of 12.5 cm and with rates of 0.3; 0.5, 0.7 and 1.0 million germinating seeds / ha with a row spacing of 25.0 cm.Accounting for the dynamics of plant density was carried out on fixed sites with an area of 1 m² in 4 times repetition. Agrotechnology was carried out generally accepted for the conditions of the zone.

3. Results and discussion
Plant density is one of the factors for a good harvest. Studying the dynamics of density when sowing winter rape of the Severyanin variety in an ordinary way with rates of 0.7; 1.0; 1.5; 2 million germinating seeds / ha with a row spacing of 12.5 cm showed that seedlings appeared, depending on the conditions of the year, on the 5th - 9th day. The number of emerging plants depended on the conditions of the year and varied according to variants. On average, in the full germination phase at a seeding rate of 0.7-1.0 million units / ha, there were 60-66 plants per 1 m². With an increase in the seeding rate to 1.5-2.0
million pieces / ha, the number of plants increased to 87 - 94, while a tendency towards a decrease in the completeness of seedlings from 86 to 47% was noted.

During the period of autumn growth and development, depending on weather conditions and density, a thinning process was observed. By the time the growing season was terminated, the number of plants decreased for all variants. On average, 51-52 plants remained on the plots before leaving for winter at a seeding rate of 0.7 - 1.0 million pcs / ha and 72-74 plants at rates of 1.5 - 2.0 million; the safety of plants was 77-85% of the number of emerged.

Thus, the increase in the seeding rate from 0.7 to 2.0 million. viable seeds / ha when sowing in a row method with a row spacing of 12.5 cm led to a decrease in the completeness of seedlings and plant safety. There were no significant differences in the number of preserved plants before wintering depending on the seeding rate.

On average, over 4 years of research, plants overwintered better in variants with a lower stand density. With a seeding rate of 1.0 million pieces / ha, 83% of the plants overwintered, with a seeding rate of 0.7 million pieces / ha - 80%. With an increase in the seeding rate to 1.5 - 2.0 million pcs / ha, the number of overwintered plants decreased to 57 - 64%.

Thus, the amount of overwintering depended on the plant density and vegetation conditions in the autumn. A decrease in overwintering was established with an increase in the seeding rate; the safety of plants in winter is higher at a rate of 0.7 and 1.0 million viable seeds / ha when sown with a row spacing of 12.5 cm.

In the spring and summer period, a further decrease in plant density was noted. At the same time, there was no clear pattern of this process depending on the seeding burrow.

When sowing with a row spacing of 25 cm, in general, the same tendencies in the dynamics of plant density were observed as with a row spacing of 12.5 cm. With an increase in the seeding rate, the completeness of seedlings, plant safety in the autumn, overwintering and plant safety in the year of harvesting for seeds decreased. On average, 3 years before harvesting, regardless of the seeding rate, there were 19 to 27 plants left (Fig. 1, b).

**Figure 1.** Dynamics of plant density with row (a) and over-row (b) sowing methods depending on the seeding rate
With a sequential method of sowing winter rape of the Severyanin variety, the greatest safety of plants by autumn was at the lowest seeding rates of 0.3 and 0.5 million pieces / ha of seeds - 82 and 93%. At higher seeding rates, plant safety was lower and amounted to 69%.

The overwintering of winter rape plants when sowing with a row spacing of 25 cm was on average higher than when sowing with a row spacing of 12.5 cm / ha 92% of plants are preserved. With an increase in the seeding rate to 0.5 million units / ha, overwintering was 86%, a further increase in the rate reduced the overwintering to 63-58%.

The data on the safety of plants for harvesting with inter-row sowing, depending on different seeding rates, showed that over three years of research, the largest number of plants was 27 pcs. 1 m 2 was at a seeding rate of 0.5 million pieces / ha. On plots with seeding rates of 0.3, 0.7 and 1 million / ha of germinating seeds, the number of plants was less.

4. Conclusion

When sown in rows with a row spacing of 25 cm, winter rape plants develop better, form a rosette of leaves with a lower location of the growth point, form a smaller amount of aboveground mass per unit of roots, which increases the safety of plants by 2.5-4.3% in winter with extreme conditions.

The study of the dynamics of the plant density of winter rapeseed at different seeding rates showed that during the growing season, self-thinning of cenosis occurs.

On average, over the years of research, plants overwintered better in variants with a lower stand density.

With an increase in the seeding rate, the completeness of seedlings, the safety of plants in the autumn period, overwintering and the safety of plants in the year of harvesting for seeds decreased.

The most optimal conditions for the safety of plants for harvesting are provided at low seeding rates: with a row sowing with a seeding rate of 0.7-1.0 million pieces / ha, with a series one - 0.5 million pieces / ha of germinating seeds: through row sowing, the safety of plants for harvesting was higher than with the row method by 9-25%.

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References
[1] Shpakov A.S., Bychkov G.N. The role of fodder production in ensuring food security in the Central Federal District // Bulletin of Russian agricultural science. - 2016. - No. 6. - p.4-7.
[2] Kosolapov V.M., et al. Forage ecosystems of the Central Black Earth Region of Russia: agricultural landscapes and technological foundations. - M.: Federal State Unitary Enterprise "Publishing House of the Russian Agricultural Academy", 2016. - 649 p.
[3] Shpakov A.S., Volovik V.T. Forage production systems in specialized livestock farms // Feed production. - 2020. - No. 3. - P. 15-19. ISBN: 1562-0417.
[4] Volovik V. T., Shpakov A. S. Scientific and practical basis of rapeseed production in the Central Federal district // IOP Conference Series: Earth and Environmental Science. – 2021. – 663. – p. 012020. DOI: 10.1088/1755-1315/663/1/012020
[5] Volovik V. T., Prologova T. V. Breeding Winter Rapeseed for the Temperate Forest Zone // Russian Agricultural Sciences. – 2017. - Vol. 43, No. 3. - PP. 213–218.
[6] Shpaar D., Adam L. Vlasenko G. (and others). Rape and rapeseed (cultivation, harvesting, use) / Ed. D. Shpaar, - M.: ID LLC "DLVAGRODELO", 2007. - 320 p.
[7] Volovik V.T., Shpakov A.S. Rapeseed production in Central Russia: state and prospects // Feed production. - 2020. - No. 10. - p. 3-9. ISBN: 1562-0417.
[8] Volovik V.T., Pampura V.D. Establishing the sowing period of winter rape variety Severyanin on the basis of morphological parameters of plant development in the autumn period // Adaptive forage production. - 2013. - No. 3 (15) - P. 31-36.
[9] Pilyuk Ya. E., Privalova FI, Zelenyak VV [et al.] Guidelines for assessing the state of rapeseed crops after overwintering and frost / Scientific-practical. Center of the National Academy of Sciences of Belarus on Agriculture. - Zhodino, 2011. - 34 p.
[10] Schulz R. R., Schumann W. Lassen sich Lachgasemissionen in Rapsgasfruchtfolgen vermeiden? // Raps, 23. – 2005. – № 4. – S. 176-80.
[11] Schulz R. R. Regeneration von Raps nach Frostschädigung // Raps. – 1997. – № 1. – S. 18-21.
[12] Schumann W. Untersuchungen zum Glukosinolatgehalt von in Deutschland erzeugten und verarbeiteten Rapssäaten und Rapsfuttermitteln // UFOP-Schriften. – 2005. - Heft 27. – S. 1-69.
[13] Kovalchuk A. M., Peresypkin V. F., Uteush Yu. A. [and others]. Methodical recommendations for growing seeds and green mass of winter rapeseed. - Kiev, 1981. - 23p.
[14] Shpaar D., Makovsky N., Samersov V.F. Rape - culture with the future // New agriculture. - 1999. - No. 1. - P. 26-29.
[15] Dridiger V.K., Guryev E. Yu. Ways of increasing the seed productivity of winter rapeseed in the Stavropol Territory // Scientific support of the rapeseed industry and ways of realizing the biological potential of rapeseed: scientific. reports at the International coortsinats. meeting on rapeseed, July 18-20, 2000 / All-Russia. nauch.-issled. and design and technology. Institute of rapeseed. - Lipetsk, 2000. - p. 136-137.
[16] Gorlov S.L., Bushnev A.S., Gorlova L.A. Compliance with technology is a guarantee of successful production of winter rapeseed in the south of Russia // Agriculture. - 2009. - No. 2. - p. 22-24.
[17] Pilyuk Ya. E. Colza in Belarus (Biology, selection and cultivation technology). - Minsk: Businessofset, 2007. - 240 p.