

DEPENDENCE OF SOYBEAN PLANT SURVIVABILITY ON THE FEEDING AREA ON TYPICAL CHERNOZEMS

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Topicality. Plant density is one of the key factors in the formation of soybean productivity, given that the most productive crops are formed with the optimal number of plants per unit area and the rational utilisation of actual environmental resources by each plant and the agrophytocenosis in general. Optimal plant spacing reduces the competition of soybean plants and ensures adequate supply of crop to soil nutrients, so both sparseness and thickness of crops significantly affect the yield shortfall. **Purpose.** To study the effect of row spacing and seeding rate on the survivability of soybean plants of early ripening varieties Vyshyvanka and Zhaklin. **Methods.** In 2021-2022, the research was conducted in scientific laboratories and stationary crop rotation by the Department of Plant Production in the fields of the Separate Subdivision Agronomic Research Station of the National University of Life and Environmental Sciences of Ukraine (Pshenychne village, Vasylkiv district, Kyiv region), in the north-eastern part of the Right-Bank Forest-Steppe of Ukraine. Phenological observations and assessment of crops were carried out according to the F. M. Kuperman's method at the main stages of plant growth and development: seedling, flower-bud formation, flowering, and ripening. The main phases of plant growth and development were noted: seedlings, budding, flowering, and ripening. The beginning of the stage was considered to be the presence of the controlled trait in at least 10 % of plants, and 75 % of plants were considered as complete stage. The plant density was recorded in the stage of full seedlings and before harvesting according to the Methodology of State Variety Testing of Crops. **Results.** It was found that plant survivability depends on the feeding area, so the greatest losses (10.3–13.2 %) of plants during the harvesting period were observed when soybeans were sown in a wide-row method (45 cm) with a seeding rate of 750 thousand seeds/ha. The lowest losses (3.4–5.3 %) were observed in the wide-row method of sowing with a seeding rate of 450 thousand seeds/ha. Soybean crops sown in a conventional row method with a row spacing of 15 cm and various seeding rates did not show any particular sparseness during the ripening period, and the death rate did not exceed 5–7 %. The best plant development occurs at the optimal feeding area with an even distribution of plants on the field. **Conclusions.** On the typical low-humus chernozems of the Forest-Steppe of Ukraine, it is recommended to sow early ripening soybean varieties using the conventional row method of sowing, with a seeding rate of 450 thousand seeds/ha that to ensure even placement of plants, optimal nutrition area and survival rate during the growing season.

Key words: soybean, variety, seeding rate, row spacing, sowing method, plant density, plant survivability

Introduction. Soybean cultivation is one of the most important areas of agriculture, as this crop is important for the production of protein feed and oil, as well as in the food and textile industries. Among agricultural crops, soybeans are of strategic importance for food security and economic development of the country. However, achieving the maximum productivity potential of soybeans is a challenge due to the multifactorial nature of the crop and its dependence on weather conditions and physiological characteristics of the plant. Therefore, the study of innovative methods and technologies that will increase the yield and quality of soybeans is an urgent

and promising scientific problem [1–4].

As a light-demanding crop, soybeans produce high yields only under optimal feeding conditions and good plant illumination. Soybean is characterised by high plasticity in relation to plant density, which manifests itself in changes in individual productivity, such as the number of nodes, branches, pods, seeds, their weight, insertion height of the lower pods, etc. [5–6].

With optimal density and plant nutrition area, the largest number of pods (64.5–70.6 %) and seeds are formed on the main stem, in sparse crops, 71.5 % of pods are formed on the side branches, and in highly dense crops, 85.2 %

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of pods are formed on the main stem [7, 8].

Soybeans respond negatively to both a decrease and an increase in plant density. On sparse crops, which are caused by non-compliance with the sowing rate and plant density, low seed quality, excessive seed depth, and soil crust formation during the period of seedling emergence, soybean plants branch out strongly, and such plants produce a lot of leaves, pods, and seeds. And, although the individual productivity of plants in such cases is high, the yield per unit area is lower than in crops with an optimal feeding area [9, 10]. Sparse soybean crops result in increased evaporation of soil moisture and create favourable conditions for weed growth. Such crops show uneven ripening of the pods, low insertion height, breaking of branches under the influence of wind, precipitation and pod weight, which leads to a decrease in yield (by 0.34–0.55 t/ha) and large yield losses [11, 12].

In dense crops, the illumination of plants, especially the branches of the lower tier, deteriorates, and leaves turn yellow prematurely, fall off, chlorophyll content and photosynthesis productivity decreases. The negative effect of excessive plant density is manifested in the formation of a thin stem, which leads to crop lodging, as well as in decrease of plant weight, number of pods and seeds. The main number of pods is located on the main stem. Lateral branches in the lower internodes and in the middle part of the stem are almost not formed. Under constant low light, no flowering occurs. Thickened crops especially reduce soybean yields in dry years [13].

The choice of sowing methods should be based on the biological characteristics of the varieties, light and hydrothermal conditions of the growing area. According to the long-term research results, the row spacing depends on the region of soybean cultivation, availability of machinery, weed infestation, soil fertility, sowing date, cultivation experience, soil condition, and early maturity of the variety. For late sowing date, narrow row spacing (15 cm) provides greater plant productivity than wide row spacing (45 cm). The row spacing should ensure high photosynthetic efficiency, in the process of which the synthesis of organic matter occurs due to the absorption of solar energy. Greater solar illumination of soybeans leads to improved protein and oil synthesis. Therefore, the

row spacing should be selected, considering that the plant cover should completely cover the row spacing before soybean flowering, because the peak consumption of photosynthetic products occurs at the reproductive stage [14, 15].

However, despite numerous publications on this issue, the opinions of researchers on the impact of sowing method and row spacing on soybean yields are quite controversial. Given the efficiency of using tractors, seeders and tillage tools, the wide-row sowing method with 45 and 70 cm row spacing is preferred. The number of germinating seeds per hectare varies from 200 to 800 thousand seeds or from 45 to 120 kg or more, depending on the growing area, soil fertility, biological characteristics of the variety, and the degree of weed infestation of the fields [1, 16].

This study was conducted to investigate the influence of row spacing and sowing rates on the survival rate of early ripening soybean varieties Vyshyvanka and Zhaklin.

Materials and Methods. The research was carried out in 2021–2022 in scientific laboratories and stationary crop rotation of the Department of Plant Science on the fields of the Separate Subdivision Agronomic Research Station of the National University of Life and Environmental Sciences of Ukraine (the Pshenychno village, Vasylkiv district, Kyiv region) located in the north-eastern part of the Right Bank Forest-Steppe and is a part of the Bila Tserkva-Myronivka natural and agricultural region, Bila Tserkva agricultural soil district.

The soil of the experimental field is a typical low-humus chernozem, with coarse dust medium loamy granulometric texture. The humus content in the topsoil (according to Tyurin) is 4.39–4.53 %; the pH of the salt extract is 6.9–7.3; the absorption capacity is 30.7–32.0 mg-eq per 100 g of soil. The total nitrogen content (according to Kjeldahl) is 0.27–0.31 %, phosphorus – 0.15–0.25 %, potassium – 2.3–2.5 %. The farm is located in a moderately warm and humid agroclimatic sub-area of Kyiv region. The average air temperature is 6.5–7.0 °C, and the relative humidity is 79 %. The average annual precipitation is 540–560 mm, with the bulk of precipitation falling in spring (120–135 mm) and summer (195–200 mm). In winter, an average precipitation is 90–100 mm, in autumn – 13–135 mm. About 65 % of precipitation falls during the

growing season, which allows growing a large number of agricultural crops.

According to the analysis of hydrothermal conditions, the temperature regime of the growing season affected soybean yield. In 2021, Ukraine had high precipitation levels, which contributed to high yields for many crops. In 2022, temperatures were lower, but still the intensity of their growth remained above the annual average. Minimum temperatures in 2021 were lower than in 2022, especially in January and February. In 2022, Ukraine experienced a lower amount of precipitation compared to the previous year. The highest temperatures were recorded in summer, especially in July and August, while the lowest temperatures were observed in February.

The three-factor experiment was as follows: factor A – Vyshyvanka and Zhaklin varieties, factor B – sowing method: 1) conventional row method with a row spacing of 15 cm, 2) wide-row method (45 cm); factor C – seeding rate: 1) 450, 2) 600, 3) 750 thousand seeds per hectare on the background of N₃₀P₆₀K₉₀. Phenological observations and assessment of crop

condition were carried out according to the method of F. M. Kuperman.

There were recorded the main stages of plant growth and development: seedlings, flower bud formation, flowering, and ripening. The occurrence of the controlled trait in at least 10 % of the plants was considered as the beginning of the stage, and 75 % of the plants were considered as complete stage. According to the Methodology of State Variety Testing of Crops, the plant density was recorded by counting the number of plants per 6.66 for conventional row sowing and per 2.22 linear metres for wide-row sowing in the stage of full seedlings and before harvesting, followed by a conversion per 1 ha [17].

Results and Discussion. In 2021–2022, on average, Vyshyvanka variety had a high rate of field germination of seed (98.2–99.8 %), which resulted in a plant density from 449 to 745 thousand plants/ha in the seedling stage, depending on the seed rate (Table 1). Field germination of Zhaklin variety seeds was slightly lower (96.8–99.3%) and the plant density in the seedling stage was 443–741 thousand plants/ha.

Table 1. Soybean plant density depending on the sowing method and seeding rates (average for 2021–2022)

Sowing method, <i>factor B</i>	Seeding rate, ths. seeds/ha, <i>factor C</i>	Development stage				
		seedling		ripening		
		plants/ m ²	%	plants/ m ²	survival rate, %	plant death dur- ing growing season, %
<i>Zhaklin variety, factor A</i>						
Conventional row method (15 cm)	450	44.7	99.3	42.8	95.7	4.3
	600	57.8	96.3	54.8	94.8	5.2
	750	72.6	96.8	68.6	94.5	5.5
Wide-row method (45 cm)	450	44.3	98.4	42.8	96.6	3.4
	600	58.6	97.7	53.7	91.6	8.4
	750	74.1	98.8	66.4	89.6	10.4
<i>LSD₀₅</i>		4.5	1.9	1.2	1.6	0.5
<i>Vyshyvanka variety, factor A</i>						
Conventional row method (15 cm)	450	44.9	99.8	42.0	93.5	6.5
	600	58.9	98.2	54.9	93.2	6.8
	750	74.5	99.3	69.4	93.2	6.8
Wide-row method (45 cm)	450	44.9	99.8	42.5	94.7	5.3
	600	59.3	98.8	53.8	90.7	9.3
	750	74.3	99.1	64.5	86.8	13.2
<i>LSD₀₅</i>		4.5	1.9	1.2	1.4	0.5

Due to uniform seedlings and high values of field germination, soybean crops developed with optimal plant density and vigorous plants that were distributed evenly over the feeding area, resulting in high crop yields [18, 19]. We

found that, the highest survival rate of plants during the growing season in variants with a row spacing of 45 cm and a seeding rate of 450 thousand seeds/ha were 96.6 % in the Zhaklin variety and 94.7 % in the Vyshyvanka

variety, depending on the feeding area. At sowing by the conventional row method, a lower percentage of plant death during the growing season at the ripening period was 4.3 % in the Zhaklin variety and 6.5 % in the Vyshyvanka variety at the seeding rate of 450 thousand seeds/ha.

In the variants with a row spacing of 45 cm and a seeding rate of 750 thousand seeds/ha, during the ripening period in the Zhaklin variety, the percentage of plant death and survival rate was 10.4 and 89.6 %, respectively, in the Vyshyvanka variety – 13.2 and 86.8 %, which significantly affected the yield structure due to the lowest plant density. Soybean crops with 15 cm row spacing were sparse, and 4.3–5.5 % of plant deaths occurred at the end of the growing season in Zhaklin variety and 6.5–6.8 % in Vyshyvanka variety, although these varieties provided good yields in rather difficult climatic conditions. The lowest death rate of soybean plants in the varieties Zhaklin and Vyshyvanka was observed under the wide-row sowing method with a row spacing of 45 cm and a seeding rate of 450 thousand seeds/ha and amounted to 3.4 and 5.3 %, respectively.

The most sparse soybean crops before harvesting were observed at a sowing rate of 750 thousand seeds/ha and a row spacing of 45 cm, as plant death reached 10.4 % in the Zhaklin variety and 13.2 % in the Vyshyvanka variety.

The final plant density of soybeans before harvesting significantly depends on the survival rate, which characterises the plant resistance to unfavourable conditions of their growing environment and depends on the characteristics of the variety and cultivation technology. Analysis of soybean plant density during the growing season showed a decrease in the number of plants in the process of their growth and development [20, 21]. Based on the analysis of the plant density at sowing by the conventional row

method (15 cm), it was noted that the plant death during the growing season in the Zhaklin variety varied within rather insignificant limits – 4.3–5.5 %, in the Vyshyvanka variety – 6.5–6.8 %, depending on the seeding rate.

The higher survival rate of soybean plants under conventional row sowing can be explained by the fact that the plants are evenly spaced over the area, which, in turn, is accompanied by better plant resistance to biotic and abiotic environmental factors. The more dense crops are sown when sowing by the wide-row method (at a seeding rate of 750 thousand seeds/ha), the lower survival rate of plants and the lower percentage of full-value seeds. In particular, in the Zhaklin variety, the lowest plant death was 3.4 % in the variant with a seeding rate of 450 thousand seeds/ha. The highest rate of plant death (10.4 %) during the growing season was observed at a seeding rate of 750 thousand seeds/ha and a row spacing of 45 cm. In the Vyshyvanka variety, the lowest rate of plant death was observed in the variant with a seeding rate of 450 thousand seeds/ha and amounted to 5.3 %. The largest rate of plant death (13.2 %) during the growing season was observed at a seeding rate of 750 thousand seeds/ha and a row spacing of 45 cm.

Conclusions. When changing the feeding area, there is a different trend in plant survival rate, thus, the highest plant death (10.4–13.2 %) during the harvesting period was observed in the variants with wide-row sowing method (45 cm) at a rate of 750 thousand seeds/ha. The lowest plant death was 3.4–5.3 % with this sowing method with a seeding rate of 450 thousand seeds/ha. Soybean crops with a row spacing of 15 cm and different seeding rates were not particularly sparse during the ripening period, and according to our research, the percentage of plant death was within 5–7 %.

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Лемешик А. В., Новицька Н. В. Визивання рослин сої залежно від площі живлення на чорноземах типових. Зернові культури. 2023. 7 (2). 296–301.

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Актуальність. Густота стояння рослин є одним із важливих чинників формування продуктивності сої, оскільки найпродуктивніші посіви формуються за оптимальної кількості рослин на одиниці площі та раціонального використання фактичних ресурсів навколишнього середовища окремо кожною рослиною і агрофітоценозом взагалі. Оптимальне розміщення рослин площею знижує конкуренцію рослин сої і забезпечує рівномірний доступ культури до поживних елементів у ґрунті, тому як зрідженість посіву, так і його загущеність суттєво впливають на недобір врожаю.

Мета досліджень. Вивчити вплив ширини міжряддя і норми висіву насіння на виживання рослин ранньостиглих сортів сої Вишиванка та Жаклін.

Методи. Дослідження проводили в 2021–2022 рр. у наукових лабораторіях та стаціонарній сівозміні кафедри рослинництва на полях ВП «Агрономічна дослідна станція» Національного університету біоресурсів і природокористування України (с. Пшеничне Васильківського району Київської області), в північно-східній частині Правобережного Лісостепу. Фенологічні спостереження та оцінку стану посівів робили за методикою Ф. М. Куперман. Відмічали основні фази росту і розвитку рослин: сходи, бутонізація, цвітіння, дозрівання. За початок фази приймали наявність контрольованої ознаки не менш чим у 10 %, за повну – у 75 % рослин. Густоту стояння рослин обліковували за Методикою державного сорто випробування сільськогосподарських культур у фазі повних сходів та перед збиранням.

Результати. Встановлено, що при зміні площі живлення спостерігається різна тенденція стосовно виживання рослин, відтак найбільші втрати (10,3–13,2 %) рослин на період збирання спостерігалися за сівби сої широкорядним способом (45 см) з нормою висіву насіння 750 тис. шт/га. Найменші втрати – 3,4–5,3 % відмічені за широкорядного способу сівби з нормою висіву насіння 450 тис. шт/га. Посіви сої звичайним рядковим способом з міжряддям 15 см та різною нормою висіву не відмічались особливими зрідженнями на період дозрівання, відсоток загибелі не перевищував 5–7 %. Кращий розвиток рослини відбувається за оптимальної площі живлення з рівномірним розподілом рослин на масиві поля.

Висновки. На чорноземах типових малогумусних Лісостепу України ранньостиглі сорти сої рекомендовано висівати звичайним рядковим способом сівби, з нормою висіву 450 тис. шт/га, що забезпечить рівномірне розміщення рослин, оптимальну площу їх живлення та виживання впродовж вегетації.

Ключові слова: соя, сорт, норма висіву, ширина міжряддя, спосіб сівби, густота стояння, виживання рослин