The structure of the yield of promising soybean varieties in the conditions of RNO-Alania

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Abstract. The purpose of the research was to study agrotechnical techniques that contribute to the growth of yields, improve grain quality and improve the technology of cultivation of promising soybean varieties in the Republic of North Ossetia-Alania. Objectives: to establish optimal sowing dates for promising soybean varieties of various ripeness, to study the influence of methods and seeding rates on the productivity of soybean varieties. We studied the influence of seeding rates and seeding methods on the growth, development and features of the production process of promising soybean varieties in the Russian Federation. We also established optimal seeding rates and seeding methods that can ensure optimal growth, development and high productivity of plants. The studies were conducted in the period 2019 - 2021, in the foothill zone of the Republic of North Ossetia – Alania, characterized as a forest-steppe with unstable moisture. The soils are represented by leached chernozems, the arable layer contains from 3 to 4.4% humus. The object of the study were the following soybean varieties: Lira - very early, Irbis - early, Frost - medium-early, Vilana – medium-ripening, Vita - very early, Slavia - medium-ripening, Iriston - medium-ripening. Field germination of seeds decreased with an increase in the seeding rate - from 83.6 to 87.9%. The highest safety of plants for harvesting was established at a seeding rate of 500 thousand/ha (94.2%), and the lowest (82.1%) - at 800 thousand/ha. The highest seed productivity of soybean plants was established at a seeding rate of 500 thousand/ha - 4.5 g. Precocious varieties reacted better to wide-row crops (45 cm). The continuous method of sowing also showed good results. On average, for 3 years, the yield of wide-row sowing was 0.18 t/ha higher than ordinary. The protein content varied slightly depending on the method of sowing, more of it was noted on wide-row crops.

1 Introduction

Soy refers to oilseeds. It is a valuable food product, as well as raw materials for the production of concentrated feed, vegetable oil, and dietary protein. It is grown in many countries of the world, different in agro-climatic conditions and economic situation [1].

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In terms of biological value, soy protein is close to animal proteins. At the same time, it is balanced in amino acid composition, contains many amino acids such as lysine, tryptophan, phenylalanine, valine, isolicine, leucine, methionine, threonine; contains up to 27% carbohydrates, vitamins A, B, B1, C, D, E and mineral salts of calcium, potassium, magnesium and phosphorus. Soybean oil is characterized by a high content of fatty unsaturated acids [2-3].

The main condition for success in the introduction of soybeans is the selection of varieties: highly productive, adapted to local conditions. One of the main requirements for them is their precocity. Currently, the precocity of zoned and promising varieties should be determined in local conditions, as well as their suitability for cultivation [4].

When studying a new variety, determining the degree of its adaptability to local soil and climatic conditions, it is necessary to analyze according to the following scheme: a specific variety, on the one hand, the length of the day (latitude of the cultivation area), the sum of active temperatures and humidification conditions - on the other. If the first two elements show the possibility of cultivating soybeans of a specific ripening period, then the third element proposes to establish – to cultivate the crop on the bogara or when watering [5].

Soy as a grain and fodder crop started to be cultivated in North Ossetia from the beginning of the organization of collective farms. In the period from 1930 to 1940 and in the first post-war years, it occupied significant areas in the republic. The further development of this crop in North Ossetia was hindered by a number of negative factors related to agricultural techniques of cultivation. One of them is the absence of precocious varieties that would ripen in the conditions of the Republic. The Harbinskaya 231 variety was high-yielding, but late-ripening, and it was very difficult to preserve its seeds in farms without much additional drying. All this led to the fact that soy was sown less in collective farms and state farms, and it was practically excluded from the structure of sown areas. However, the North Ossetian Agricultural Experimental Station, taking into account the great value of the culture, did not stop breeding it. As a result, there was bred the variety Ossetinskaya 132, zoned in 1962, and the variety Ossetinskaya 19 was proposed for zoning. Therefore, the selection of new more adapted varieties and the development of individual elements of their agricultural technology is an urgent task of science and production [6-7].

Considering that some agrotechnical practices that were developed in the past years were insufficient to identify the bioresource potential of new soybean varieties of various ripeness groups, as well as due to changes in some climate parameters, the introduction of new highly productive varieties into production, the development of mechanization and new fertilizing preparations requiring a different approach to soybean cultivation technology, there was a need a more complete study in the zonal context of the influence of the studied agrotechnical factors on the growth, development and productivity of soybeans [11-12].

2 Materials and methods

The research was carried out on the experimental field of the North Caucasus Research Institute of Mountain and Foothill Agriculture of the VNTS RAN in the conditions of the forest–steppe zone of RNO-Alania.

A distinctive feature of the forest-steppe zone is the onset of spring somewhat later than in the steppe. The annual sum of effective temperatures here is 3570-3890°C. Spring frosts are sometimes observed in the second decade of April, autumn frosts – in the third decade of October. It is divided into two subzones according to the amount of precipitation: a) sufficient moisture, b) unstable moisture. Most of all precipitation (75%) falls in late May - early June. According to long-term data, the duration of the frost-free period is 193-214
Relative humidity is quite high throughout the year (75-85%), which has a positive effect on the growth and development of most crops.

Two main types of soils prevail: chernozems of varying degrees of leaching, as well as meadow and meadow-swamp soils. The arable layer contains from 3 to 4.4% humus. The reaction of the soil solution in the upper horizons is neutral, deeper than 80-90 cm – slightly alkaline.

During the research, 6 soybean varieties of the selection of "FGBNU FNTS VNIIMK" were studied - Lira, Vita, Irbis, Rime, Vilana, Slavia. As a control variant, the soybean variety Iriston was sown by OOO Research Institute "IRAGRO".

2.1 Scheme of experiment

2.1.1 Experiment No. 1. – Sowing dates and soybean productivity

- The first sowing period (t of soil at the depth of seeding 8-10 °C).
- The second sowing period (t of the soil at the depth of seeding 12 °C).
- The third sowing period (t of soil at the depth of seeding 14-16 °C).

2.1.2 Experiment No. 2. - The influence of sowing methods on the productivity of promising soybean varieties

- Row planting (15cm).
- Wide-row planting (45cm).
- Strip planting (15×45cm).

2.1.3 Experiment No. 3 – The influence of the seeding rate on the productivity of various soybean varieties

- Irbis, Lira, Vita: 1. 400 thousand/ha; 2. 500 thousand/ha; 3. 600 thousand/ha.
- Iriston, Slavia, Vilana, Rime: 1. 500 thousand/ha; 2. 600 thousand/ha; 3. 700 thousand/ha.

The experiments were laid on the experimental fields of the department of adaptive landscape agriculture according to the generally accepted methodology on plots in three-fold repetition. The total number of plots is 63. The size of the plots: length – 5.1 m, width – 3m. Side protective strips – 0.5 m. The total area of the experiment is 963.9 m². The arrangement of variants in repetitions is randomized.

The laying and cleaning of the experiments were carried out manually.

During the growing season, in order to solve the tasks set, the following was done:

- Phenological observations by the method of ocular evaluation in two non-contiguous repetitions of the development and growth of plants. The presence of a certain sign in 10-15% of plants on the plot was taken as the beginning of a new phase, in 75% of plants - it was considered as a complete phase.

- The leaf area was taken into account by the die-cutting method. For this purpose, plants were selected from a certain area, their leaves were torn off and weighed (A.A. Nichiporovich, 1971). The leaf area was determined (S, cm²), knowing the total mass of the leaves, the area and the mass of the cuttings [8].

$$S = \frac{P \cdot J \cdot n}{P_1}$$  \hspace{1cm} (1)
Where: \( J \) – the area of one die–cutting, \( \text{cm}^2 \); \( n \) – the number of die–cuttings; \( P \) – total weight of leaves, g; \( P_1 \) – mass of die-cuttings, g.

Knowing the density of plant sowing and the area from which samples were taken, we calculated the leaf area from 1 ha.

- The net productivity of photosynthesis (NPF) was determined by the formula:

\[
\text{NPF} = \frac{B_2 - B_1}{(L_1 + L_2) \cdot 0.5 \cdot T}
\]  

Where: NPF – the amount of dry mass formed during the considered period of time (T) per 1 \( \text{m}^2 \) of leaves, g/\( \text{m}^2 \) day; \( B_2 - B_1 \) – the increase in dry weight for the accounting period, g; \( (L_1 + L_2) \cdot 0.5 \) – average leaf area for a given period of time, \( \text{m}^2 \); \( T \) – the number of days in the accounting period of time.

- Crop accounting was carried out by the method of trial sites, followed by its recalculation to 100% purity and conditioned humidity.

- In the grain mass, the following was determined: protein – by Kjeldahl method, fat – by the method of fat-free residue extraction in the Soxhlet apparatus.

- Records and observations were carried out according to the methods described in the "Educational and methodological guide for conducting research in agronomy" (E.D. Adinyaev, A.A. Abaev, N.L. Adaev, 2012) [9].

- Statistical processing of the obtained data was carried out by the method of variance analysis (B.A. Dospekhov, 2013) [10].

3 Results and Discussion

It was found that in the third term, soybean crops were more leafy. In the studied varieties, the duration of interphase periods varied from the time of sowing. The duration of interphase periods was influenced by: temperature regime and lack of moisture in summer.

The correct choice of the soybean feeding area is an important element in the technology of its cultivation. The duration of the growing season, timing and seeding rates were not significantly affected. On experimental soybean crops, seedlings appeared on 8-10 days, depending on the variety. The period of "sprouting – flowering" was according to varieties: Irbis – 30–33 days, Vita – 34–37 days, Lira – 39–42 days, Iriston – 40–45 days, Inej – 43–45 days, Slavia – 42–47 days, Vilana – 45–48 days. Early varieties are marked by fewer intermediate interphase periods. The duration of the growing season by varieties: Irbis – 92 days, Vita – 96 days, Lira – 100 days, Iriston – 110 days, Inej – 111 days, Slavia – 116 days, Vilana – 115 days.

It was revealed that by the ripening phase, the height of plants sown in the first sowing periods form taller plants, where the difference was from 10-20 cm.

The highest plants were noted at the third sowing period (May 16) in all the studied varieties: Iriston – 130 cm, Vita – 98 cm, Irbis – 105 cm, Inej – 108 cm, Lira – 83 cm, Vilana – 115 cm, Slavia – 120 cm. Before the "branching" phase, the average daily increase was not significant – 0.7-0.8 cm, and later the seeding rate affected the increase in plant height.

From "flowering to the appearance of beans", the increase in the Irbis variety was 23 cm (the seeding rate of 500 thousand pcs/ha), and at the rate of 700 thousand pcs/ha – 26.3 cm. During the "bean filling" phase, the tallest plants were noted, during the "branching" phase, the highest productivity of the green mass was obtained from the Iriston variety, where it was 3.98 t/ha (seeding rate of 700 thousand pcs/ha), and at the seeding rate of 500 thousand pcs/ha, it was 0.11 t/ha more. In the varieties of Irbis, Lira, this difference
was insignificant and equal to 0.08-0.13 t/ha, in the varieties of Slavia, Vita, Vilana, Inej it noticeably changed, in the limits of 0.39 - 0.95 t/ha. During the entire growing season, the highest values for all varieties were noted during the "branching - flowering" period. During the "flowering – appearance of beans", the growth of the green mass of the Iriston variety decreases. At seeding rates of 500 thousand pcs/ha, the increase was of the greatest importance. During the period of "bean filling", the accumulation of green mass according to the studied options was maximum. According to the Iriston variety, during this period, with sowing rates of 600 and 700 thousand pcs/ha, the yield did not change significantly and was equal to – 19.91-20.41 t/ha. According to the Iriston variety, during this period, with sowing rates of 600 and 700 thousand pcs/ha, the yield did not change significantly and was equal to – 19.91-20.41 t/ha.

It was revealed that the leafiness of plants is influenced by the seeding rate. The leafiness of plants decreased with increasing of seeding rate. The best indicators for the foliage of plants in our studies were obtained at a seeding rate of 500 thousand pcs/ha.

The minimal leaf area was at a late sowing date. When sowing soybeans (April 26), we observed the most developed assimilation surface – 46.9 thousand m²/ha. There was a decrease in leaf area by 3.3 thousand m²/ha when sowing soybeans (May 6).

The highest values of photosynthesis productivity were noted during the growing season "the beginning of flowering". The lowest values of the NPF were observed at the end of the growing season, and the highest – during late sowing dates.

It was found that the photosynthetic potential of crops varied depending on the studied variants and varieties in the range of 1851-3372 thousand m² days/ha. The assimilation apparatus was formed most intensively in the phase of "flowering - the beginning of bean formation". The increase in the NPF was observed during the period of "seed filling". The Iriston variety had the highest NPF rates, with a norm of 700 thousand/ha, the average daily increase in dry matter was 0.037 t/ha. According to the variants of our studies, it was found that a decrease in the seeding rate leads to a decrease in the average daily increase. With an increase in the seeding rate, the average daily increase in dry matter multiplied and amounted to 4.72 t/ha for the Iriston variety, and a decrease in the seeding rate to 500 thousand pcs/ha reduced its accumulation by 0.31 t/ha. The same trend is observed for the Irbis variety.

For the varieties Slavia and Lira, the maximum indicator was noted at seeding rates of 500 and 600 thousand/ha in the range of 6.32–6.43 t/ha for the Lira variety and 6.60 – 6.98 t/ha for the Slavia variety.

According to the studied soybean varieties, at the sowing date (April 26), the yield varied in the range of 1.74-2.50 t/ha, in the second period – 1.90–2.52 t/ha, in the third – 1.95–2.93 t/ha (Figure 1).

The Vita variety was characterized by the lowest yield, and Irbis and Vilana varieties were characterized by the highest. The yield of the studied varieties in the third sowing period relative to the first was higher by 0.10-0.65 t/ha.

The Iriston variety has the highest seed productivity of plants with a seeding rate of 500 thousand pcs/ha – 7.5 g, and the Irbis variety – 8.1 g, with a seeding rate of 600 thousand pcs/ha and 700 thousand pcs/ha, productivity decreases by 1.5 and 2.0 g, respectively (Table 1).
Fig. 1. Yield of soybean seeds depending on the sowing dates in the conditions of the foothill zone of RNO-Alania, t/ha.

Table 1. The structure of the yield of promising soybean varieties depending on the seeding rate in the conditions of forest-steppe zones of RNO-Alania.

<table>
<thead>
<tr>
<th>Seeding rate, thousand/ha</th>
<th>Content, %</th>
<th>Quantity, pcs.</th>
<th>Weight, g</th>
<th>Yield, t/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>protein</td>
<td>fat</td>
<td>beans from one plant</td>
<td>seeds from one plant</td>
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<tr>
<td>Iriston</td>
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<td>500</td>
<td>41.2</td>
<td>18.7</td>
<td>16.3</td>
<td>39.8</td>
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<td>600</td>
<td>40.1</td>
<td>18.4</td>
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<td>37.7</td>
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<td>700</td>
<td>40.1</td>
<td>18.2</td>
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<tr>
<td>NSR 05 (least significant difference)</td>
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<tr>
<td>Irbis</td>
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<td>41.3</td>
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<td>19.2</td>
<td>21.6</td>
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<td>40.4</td>
<td>19.4</td>
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<tr>
<td>NSR 05 (least significant difference)</td>
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<td>Lira</td>
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<td>Slavia</td>
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<td>Vita</td>
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<td>Vilana</td>
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<td>NSR 05 (least significant difference)</td>
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</table>
According to the Irbis variety, the mass of 1000 seeds at a seeding rate of 700 thousand/ha was 180 g, and at a rate of 500 thousand/ha it increased to 185 g.

The number of beans from one plant and seeds of one bean varied slightly. A similar picture developed for the Slavia variety, where at a seeding rate of 700 thousand/ha, the mass of 1000 seeds decreased by 15 g., and the number of seeds per plant by 2.6 g.

In the varieties Iriston and Irbis, a decrease in seed productivity on average per plant, with an increase in the seeding rate, was accompanied by an increase in yield due to compensation by a large number of plants per unit area.

With an increase in the seeding rate from 500 to 600 thousand/ha in the varieties of Lira and Vita, the seed weight decreased by 0.2 g, the number of beans - by 0.2 and 1.4 pcs., seeds from one plant – 1.6 and 0.2 pcs.

The maximum biological yield for the Lira variety was 2.74 t/ha at a seeding rate of 600 thousand/ha, and the biological yield for the Slavia variety was 2.71 t/ha. An increase in the seeding rate led to an increase in yield.

4 Conclusion

At the first sowing period, the yield of the studied varieties varied within the range of 1.74 – 2.50 t/ha. The second and third sowing periods showed similar indicators of: 1.90 – 2.52t/ha and 1.95 – 2.93 t/ha. The Vita variety was characterized by the lowest yield, and Irbis and Vilana varieties were characterized by the highest yields. Taller plants were formed in the early sowing periods than in the later ones.

When sowing at the optimal time, the seeding rates did not affect the duration of the growing season. Early-maturing varieties were characterized by shorter interphase periods. The duration of the growing season by varieties: Irbis – 92 days, Vita – 96 days, Lira – 100 days, Iriston – 110 days, Inej – 111 days, Slavia – 116 days, Vilana –115 days.

The greatest leafiness of plants of the Iriston variety both in the branching phase (58.3%) and the appearance of beans (45.2%) was noted at a seeding rate of 500 thousand/ha. The photosynthetic potential of crops varied depending on the studied varieties and variants in the range of 1851-3372 thousand m² days/ha.

The mass of 1000 seeds of the Iriston variety decreased from 185 g at a seeding rate of 500 thousand/ha to 180 g at a seeding rate of 700 thousand/ha. The number of beans from one plant and seeds of one bean practically did not change. An increase in the seeding rate led to an increase in yield.

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