

The effectiveness of cultivating soybean varieties of different maturity groups in the conditions of the central Ciscaucasia

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Abstract. The studies were conducted in 2017-2019 at the experimental station of the Stavropol State Agrarian University in conditions without irrigation and on the basis of the experimental plots of Agrosakhar LLC with the use of irrigation. The territories of the research sites belong to the zone of unstable humidification, characterized by unstable and uneven precipitation during the growing season of soybeans, elevated air temperatures in summer, when soybean plants enter the phases of flowering and grain filling. At the experimental plots of the SSAU experimental station, the soil is represented by leached chernozem, at the experimental sites of Agrosahar LLC by ordinary chernozem. The purpose of the research is to determine the biological characteristics and efficiency of growing new, promising soybean varieties of the southern ecotype. It was found that the most quickly-ripening variety with a growing season of 96 days is the Bara variety, the longest growing season was noted in the mid-ripening Vilana variety – 129 days. The maximum photosynthetic potential of soybean crops was formed under irrigation conditions: quickly-ripening Selecta 101 variety – 1376, early-ripening Duar variety – 1678 and mid-ripening Zara variety – 2167 thous. m².day/ha. In terms of yield, when growing soybeans without irrigation in the quickly-ripening group, the Lira variety stood out – 1.59 t/ha, in the early-ripening Selecta 201 variety – 1.75 t/ha and the mid-ripening Zara variety – 1.94 t/ha, when irrigation was used in the quickly-ripening group, the Selecta 101 variety stood out – 2.34 t/ha, in the early-ripening Duar variety – 2.89 t/ha and the mid-ripening Zara variety – 3.14 t/ha. In the conditions of the SSAU experimental station without irrigation and in Agrosakhar LLC the largest profit in the amount of 16028 to 40912 rub./ha was obtained by cultivating the mid-ripening Zara variety with a yield of 1.94 - 3.14 t/ha, and the level of profitability ranged from 49.4 to 108.8%.

1 Introduction

The most important task in the agriculture of the Russian Federation is the production of high-quality seed material, which will allow, in accordance with the decree of July 21, 2016 of the President of the Russian Federation V.V. Putin to provide the country with food

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independence [1]. In recent years, over the period from 2011 to 2021, the acreage under the leading leguminous crop – soybeans in the Russian Federation increased 2.6 times from 1.2 to 3.1 million hectares, this was facilitated by the adoption of the Target Industry Program "Development of soybean production and processing in the Russian Federation for the period 2014-2020" [2,3,4]. Average yield in the North Caucasus Federal District for 2021 was 1.98 t/ha. The expansion of the acreage of legumes, including soybeans, makes it possible to solve the problem of plant protein deficiency, but grain production should increase primarily by increasing the yield and quality of grain, which is ensured by compliance with cultivation technology, an important part of which is the variety [5,6,7]. Thus, at present, the selection of the most productive varieties adapted to the soil and climatic conditions of the growing zone is one of the primary tasks in the agro-industrial complex. To complete the growing season, soybean varieties require a sum of active temperatures from 1700 to 2900 °C [8,9,10]. As scientific and industrial experience shows, in the conditions of the Stavropol Territory, if there are sufficient thermal resources, it is possible to grow quickly-ripening varieties with a growing season of 91-110, early-ripening varieties – 111-120 and mid-ripening varieties – 121-130 days, the limiting factor of soybean cultivation in the region is the presence of sufficient moisture [11,12,13]. The purpose of the research is to determine the biological characteristics and efficiency of growing new, promising soybean varieties of the southern ecotype created on the basis of the Armavir Experimental Station and at the Research Center of the All-Russian Research Institute of Oilseeds named after V. S. Pustovoit in a zone characterized by unstable humidification.

2 Research methodology

The studies were conducted in 2017-2019, in the conditions of the zone of unstable humidification of the Stavropol Territory on the territory of the experimental station of the Stavropol State Agrarian University without irrigation and in the conditions of Agrosakhar LLC with irrigation. The placement of variants in the experiment was systematic by the method of organized repetitions, the area of the registration plot was 21 m², the repetition was fourfold. At the SSAU experimental station, the soil is represented by leached chernozem, on the experimental fields of Agrosakhar LLC by ordinary chernozem. As objects, the varieties of the quickly-ripening group were studied: Lira, Selecta 101, Bara, varieties of the early-ripening group: Duar, Selecta 201, Duniza and the mid-ripening group: Vilana, Vestochka, Zara. The standard varieties were: Lira (St 1), Duar (St 2) and Vilana (St 3). Agrotechnics are generally accepted for the growing area, the predecessor in the experiments was winter wheat [14]. The establishment of experiments, records and observations were carried out in accordance with the "Methodology of field experience" [15], "Methodology of conducting field agrotechnical experiments with oilseeds" [16]. Statistical processing of the obtained data was carried out in the Excel program.

3 Results and discussion

The weather conditions that developed during the years of research in the conditions of the SSAU experimental station and Agrosakhar LLC had differences (Table 1). For the group of quickly-ripening varieties – Lira, Selecta 101 and Bara, the highest temperature regime with the sum of active temperatures for the growing season 2409 - 2469 °C was noted in 2018.

Table.1 Weather conditions during the research period.

Maturity group	SSAU experimental station (without irrigation)						Agrosakhar LLC (with irrigation)					
	amount of precipitation, mm			$\Sigma t \geq 10^{\circ}\text{C}$			amount of precipitation, mm			$\Sigma t \geq 10^{\circ}\text{C}$		
	2017	2018	2019	2017	2018	2019	2017	2018	2019	2017	2018	2019
quickly-ripening	249	134	141	2389	2469	2397	239	97	125	2349	2409	2280
early-ripening	264	144	206	2718	2527	2561	240	106	154	2584	2681	2774
mid-ripening	264	174	206	2834	2771	2723	245	121	175	2872	2799	2850

For the group of early-ripening varieties – Duar, Selecta 201 and Duniza, the largest sum of active temperatures occurred in 2017 in the conditions of the experimental station - 2718 °C and for 2019 – 2774 °C in the conditions of Agrosakhar LLC. During the growing season of mid-ripening varieties - Vilana, Vestochka and Zara, the largest sum of active temperatures 2872-2834 °C was in 2017. In the conditions of the SSAU experimental station without irrigation, 2017 was the most provided with precipitation. The hydrothermal index for all varieties was 1.1-1.3 in 2018-2019. The hydrothermal index was in the range from 0.5 to 0.6. In the conditions of Agrosakhar LLC during the years of research, compared with the experimental field of the experimental station, almost the same amount of precipitation fell, while taking into account the presence of soil moisture, watering of soybean crops was carried out, the average irrigation rate was 250-350 m³/ha, depending on the prevailing weather conditions, 4 to 6 irrigations were carried out.

Depending on the year of research and the variety, the growing season in the group of quickly-ripening varieties ranged from 96 to 113 days, in the group of early-ripening varieties from 111 to 128 days and mid-ripening from 121 to 136 days (Table 2).

Table 2. Soybean growing season.

Variety	Growing season, days							
	SSAU experimental station (without irrigation)				Agrosakhar LLC (with irrigation)			
	2017	2018	2019	Average	2017	2018	2019	Average
Lira (St ₁)	113	107	109	110	106	100	109	105
Selecta 101	111	104	106	107	104	100	109	104
Bara	99	100	96	98	96	91	101	96
Duar (St ₂)	128	114	118	120	114	112	117	114
Selecta 201	125	112	120	119	117	115	119	117
Duniza	118	111	114	114	116	107	113	112
Vilana (St ₃)	136	124	128	129	128	123	129	127
Vestochka	134	122	128	128	127	126	133	123
Zara	130	121	126	126	127	120	122	120

On average, in 2017-2019, the varieties Selecta 101 and Bara had a growing season in conditions without irrigation for 3 to 12 days, and with irrigation for 1 to 9 days was shorter compared to the standard variety Lira. The growing season of the early-ripening variety Selecta 201 was at the level of the standard Duar variety, the Duniza variety matured earlier than the standard variety by 2 to 6 days. The period from germination to maturation in the mid-ripening Zara variety, both in conditions without irrigation and when watering plants, compared to the standard Vilana variety, was shorter by 3-7 days.

The maximum increase in the leaf area by soybean plants occurred during the longest phases of plant development – flowering and bean formation, it was found that the photosynthetic potential of soybean crops differed significantly both in the studied varieties and growing conditions (Figure 1).

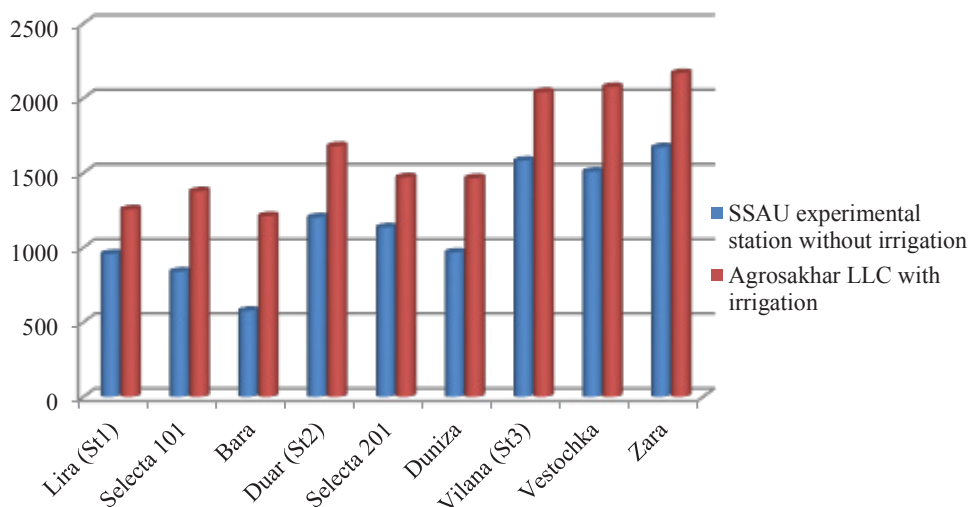


Fig. 1. Photosynthetic potential of soybean crops in the interphase period flowering – bean formation depending on the variety and growing conditions, average for 2017-2019, thous. m²·day/ha (LSD₀₅ – 320 – SSAU experimental station; LSD₀₅ – 316 – Agrosakhar LLC).

On average, over three years of research in the group of quickly-ripening varieties in the conditions of the SSAU experimental station, the highest photosynthetic potential of soybean crops was established in the standard variety Lira - 957 thous. m²·day/ha, the photosynthetic potential of crops of the Bara variety was significantly less than the standard variety. When irrigated under the conditions of Agrosakhar LLC, the photosynthetic potential of crops of quickly-ripening soybean varieties varied from 1210 to 1376 thous. m²·day/ha. In the group of early-ripening varieties, the greatest formation of the photosynthetic potential of crops was noted in the standard Duar variety - 1201-1678 thous. m²·day/ha. The photosynthetic potential of crops of mid-ripening varieties ranged from 1501 to 1670 (SSAU experimental station) and from 2141 to 2167 (Agrosakhar LLC) thous. m²·day/ha. In general, it can be noted that under irrigation conditions, the photosynthetic potential of crops was 1.3- 1.6 times larger.

It was found that the yield of soybean varieties differed significantly and varied in the range from 1.45 to 1.94 (SSAU experimental station) and from 2.12 to 3.14 (Agrosakhar LLC) t/ha. On average for 2017-2019 in conditions without irrigation, the yield of quickly-ripening varieties of Selecta 101 and Bara was 1.45 - 1.54 t/ha, which is less than the standard Lira by 0.05 - 0.17 t/ha, in irrigation conditions, varieties of Selecta 101 and Bara exceeded the yield of the standard by 0.06 – 0.28 t/ha. The highest yield in the group of early-ripening varieties was obtained by the Selecta 201 variety – 1.75 (SSAU experimental station) and the standard Duar variety - 2.89 (Agrosakhar LLC) t/ha (Fig.2). The yield of the Selecta 201 variety was 1.75 – 2.77, and the Duniza variety was 1.61 – 2.80 t/ha, the increase in yield compared to the standard variety was within the error of the experiment. In the group of mid-ripening varieties, the standard variety of Vilana was obtained under the conditions of the SSAU experimental station without irrigation, 1.78 t/ha, and in the conditions of Agrosakhar LLC with irrigation - 2.92 t/ha, which is more by 1.14 t/ha, a reliable increase was obtained

by the Zara variety with a yield of 1.94 – 3.12 t/ha, which was – 1.94 - 3.14 t/ha. The yield of soybeans in the conditions of the zone of unstable moistening with irrigation was significantly higher on average by 1.3 - 1.6 times, depending on the variety, compared with growing soybeans without irrigation.

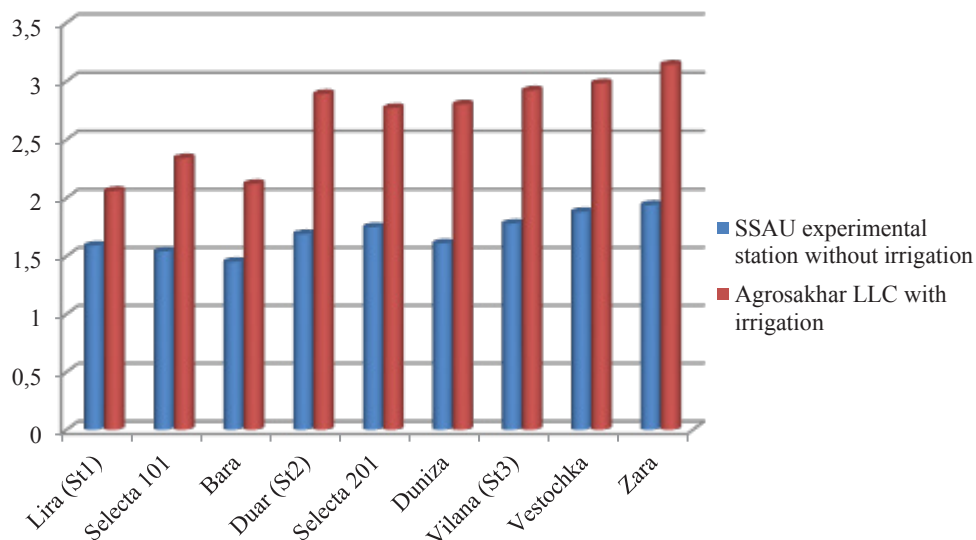


Fig. 2. Soybean yield depending on the conditions of cultivation, on average for 2017-2019, t/ha (LSD₀₅ – 0.17 – SSAU experimental station; LSD₀₅ – 0.13 – Agrosakhar LLC).

In order to determine the efficiency of cultivation of the studied soybean varieties, calculations of the main economic indicators were carried out. Labor costs for growing soybean varieties in an unstable humidification zone without irrigation ranged from 32,308 to 32,472 rubles per hectare, the cost of the resulting products ranged from 1,738 to 2,262 rubles per ton of grain. (Figure 3).

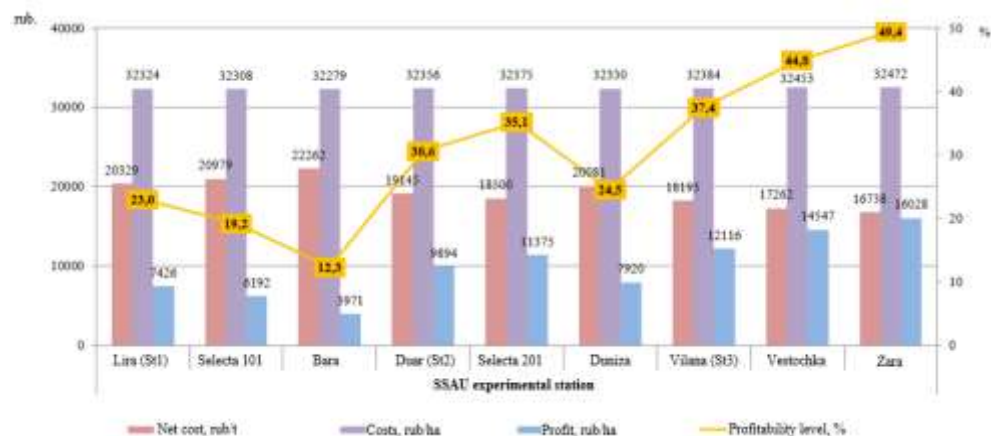


Fig. 3. Economic efficiency of soybean cultivation in the conditions of the SSAU experimental station, on average for 2017-2019.

The profit of the received products varied from 6,192 to 16,028 rubles per hectare, and the level of profitability from 12.3 to 49.4%. Thus, the largest profit in the amount of 16,028 rubles/ha was obtained when cultivating the Zara variety with a yield of 1.94 t /ha, and the

profitability level was 49.4%. The lowest profit in the amount of 3,971 rubles/ ha, as well as the lowest level of profitability – only 12.3% were obtained when cultivating the Bara variety with a yield of 1.45 t/ha. The results of calculations also indicate that in the conditions of the SSAU experimental station, the cultivation of soybean varieties with a yield of 1.3 t/ha will be critical, and with a yield below this value, it will be unprofitable. In the conditions of Agrosakhar LLC, labor costs in the application of irrigation ranged from 37,245 to 40,912 rubles per hectare, the cost of the products received ranged from 11,971 to 18,080 rubles per ton of grain, and the level of profitability varied from 38.3 to 108.8%. The most effective is also the cultivation of the Zara variety with a maximum yield of 3.14 t/ha among the studied varieties, where the profitability level was 108.8% (Figure 4).

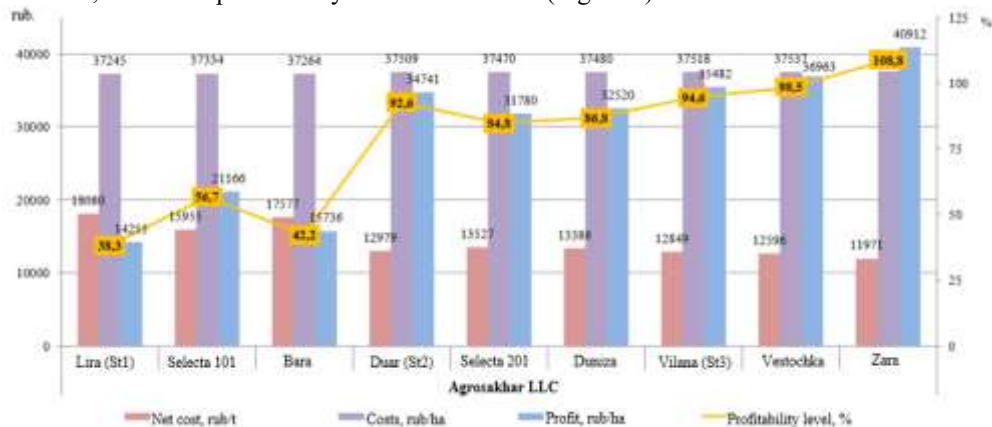


Fig. 4. Economic efficiency of soybean cultivation in the conditions of Agrosakhar LLC, on average for 2017-2019.

The lowest profit was obtained when cultivating the Lira variety with the lowest yield – 2.06 t/ha, and the level of profitability – only 38.3%.

4 Conclusion

In the conditions of the zone of unstable humidification, the Stavropol Territory, on average, over three years of research, the vegetation period in the conditions of the SSAU experimental station was 105 days for quickly-ripening varieties, 118 days for early-ripening and 128 days for mid-ripening varieties, when growing soybeans in Agrosahar LLC, 102 days for quickly-ripening, 114 days for early-ripening and 123 days for mid-ripening varieties. The photosynthetic potential of soybean crops depends both on the varietal characteristics of soybeans and on the growing conditions. The highest activity of the photosynthetic apparatus was noted in the varieties of the mid-ripening group, both in conditions without irrigation and with irrigation. The greatest photosynthetic potential was noted in the varieties of the mid-ripening group Vilana, Vestochka and Zara, which ranged from 1508 to 1670 in the conditions of the SSAU experimental station and from 2041 to 2167 thous. m2.day/ha in the conditions of Agrosakhar LLC. With irrigation, a significant increase in both the leaf area and the increase in the photosynthetic potential of crops by 1.3 - 1.4 times compared to conditions without irrigation was noted. The highest photosynthetic activity in the group of quickly-ripening varieties in conditions without irrigation was possessed by the standard variety Lira – 957 thous. m2.day/ha, with irrigation, the variety Selecta 101 – 1376 thous. m2. The yield of the quickly-ripening Lira variety in conditions without irrigation was the highest – 1.59 t/ha, in irrigation conditions the Selecta 101 variety was the highest-yielding – 2.34 t/ha. In the group of early-ripening varieties, the standard

Duar variety under irrigation conditions was the highest yielding - 2.89 t/ha. The mid-ripening Zara variety exceeded the yield of the standard Vilana variety by 0.16 - 0.22 t/ha. The most effective from an economic point of view is also the cultivation of the Zara variety under irrigation conditions with a maximum yield of 3.14 t/ha among the studied varieties, where the profitability level was 108.8%

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