

Retrospective analysis of soybean varietal potential in conditions of the south of the Non-Black Earth Region

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Abstract. Soybean is the most important agricultural crop, necessary to meet the needs of the population and livestock industries with highly digestible vegetable protein. The article contains a retrospective analysis of soybean cultivation in the Russian Federation and Ryazan region. The factors of the growing popularity of this agricultural crop were determined and included high marginality, significant content of highly digestible protein, amino acids and minerals, resistance to diseases and pests. The factors that had the greatest impact on the yield and quality of soybeans were identified - these were natural and climatic conditions, soil fertility, applied agricultural methods of cultivation, and the choice of variety. The conducted 5-year retrospective analysis showed that more than 50% of agricultural enterprises in Ryazan region incorrectly selected a variety for cultivation. As a result, the actual yield was lower than the potential. In this regard, the article provides recommendations for adjusting the economic activities of agricultural enterprises.

1 Introduction

Soybean cultivation is currently a promising growth point for the agricultural sector of the Russian Federation, since plant proteins are a more economical addition to traditionally used animal proteins [8].

Soybean is a highly profitable crop that meets the needs of many regions of the planet for protein food and feed products, vegetable oil. The development of modern agricultural technologies makes it possible to grow soybeans in 94 countries with different soil and climatic conditions and on almost all continents of the planet, far beyond the region of its origin [4, 6].

Soybeans and their processed products are the main diet of residents of the Asia-Pacific region, South and North America. With the growth of population and standard of living in these regions, there is a need to increase the production of isolates, texturates and concentrates for the production of tofu, soy milk and other traditional products [8].

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2 Materials and methods

At the same time, soybean processing products do not fully meet the established taste preferences of Russians, and this is despite the fact that due to the unique amino acid composition of the protein in combination with fatty acids and a huge number of biologically active substances, soybeans are irreplaceable for the prevention and reduction of the risk of various diseases [8].

The dynamic growth of the soybean market opens up significant opportunities for Russian agricultural producers. This is facilitated by the presence in the Russian Federation territories having favorable natural conditions for its cultivation and the prospect of their expansion, as well as geographical proximity to potential importers of products [3].

And if several decades ago the traditional regions of soybean cultivation in the Russian Federation included exclusively the Far East and Kuban, then at present soybean cultivation is possible in the Volga region, the Central Black Earth Region, the Non-Black Earth Region and more northern regions [4, 7].

3 Results and Discussion

In Ryazan region, located in the southern part of the Non-Black Earth Region of Russia, until recently soybeans were cultivated by individual agricultural enterprises. A sharp increase in soybean production in the region has been observed since 2019 (Table 1).

Table 1. Dynamics of development of soybean seed production in Ryazan region in 2015-2024.

Parameter	Year									
	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Sown area, thousand hectares	858.8	874.8	883.4	883.2	951.4	1002.5	1066.5	1118.9	1122.1	1140.6
Sown area of soybeans, thousand hectares	10.0	10.5	15.3	16.5	30.4	41.9	59.7	80.0	96.0	125.9
Share of soybeans in the structure of sown areas, %	1.2	1.2	1.7	1.9	3.2	4.2	5.6	7.2	8.6	11.0
Gross soybean harvest, thousand tons	16.3	19.3	18.2	17.2	55.5	80.0	91.8	132.7	220.3	261*
Soybean yield in Ryazan region, c/ha	16.3	18.5	12.2	11.1	18.3	19.1	15.4	17.6	21.9	20.7*

* preliminary data

Analysis of the data in Table 1 shows that over 10 years, the soybean sowing area in Ryazan region has increased more than 12 times, the gross harvest in 2024 was a record for the region and amounted to 261 thousand tons according to preliminary data, which was 16 times higher than in 2015. The most significant increase in soybean production in our region has been observed since 2019 and the annual increase in soybean sowing areas ranges from 20.0% to 84.2%.

A significant increase in soybean production was due not only to an increase in the area of its cultivation, but also to the improvement of cultivation technologies, with the emergence of new high-yielding varieties adapted to local growing conditions and possessing high technological properties.

According to scientists, the direct contribution of a variety to the overall increase in yield for individual agricultural crops can reach up to 50% [1, 6]. For example, in Canada,

where soybean varieties for the temperate climate zone are grown, an increase in the yield of early-ripening varieties by 20% was achieved through selection work, and the overall increase in yield over twenty years due to variety change only was 0.7% [4].

Modern soybean varieties in demand in agricultural production must have a whole range of valuable characteristics: stable high productivity, resistance to abiotic and biotic factors, increased adaptability to hydrothermal variations, and the implementation of varietal potential with efficient use of environmental resources.

In recent years, there has been a trend toward an increase in the heat supply of agricultural crops throughout the territory of the agricultural zone of the Russian Federation. This is due to an increase in the average annual air temperature in Russia by 0.49 °C over the past 10 years, which is 2.5 times higher than the rate of increase in global temperature over the same period.

On the one hand, this trend contributes to the expansion of the soybean cultivation area, on the other hand, it leads to an increase in the duration of the growing season [6].

According to experts, the expansion of the northern boundaries of the soybean cultivation area by at least 1° north latitude should be accompanied by the introduction of a new variety [4-5].

The successes of domestic breeding, associated with the emergence of soybean varieties of the northern ecotype, contributed to the expansion of the crop into new regions of cultivation, but the problems of obtaining stable yields and quality of soybean grain remain relevant.

The implementation of the biological potential of soybean varieties largely depends on adaptation to stress conditions: changes in temperature conditions caused by spring or autumn frosts, increased soil acidity, intense insolation, etc. [1]. Moreover, these stress factors can vary significantly within a region, where several agroclimatic zones are distinguished.

The main criteria for choosing a soybean variety for specific growing conditions include the length of the day, the sum of active temperatures and moisture conditions, which are indicators of the possibility of growing a variety of a specific ripening period [2].

Ryazan region is located on the border of effective soybean production and, in general, the climatic conditions of the region meet the requirements of the crop (Table 2).

Table 2. Agroclimatic parameters of Ryazan region from April to September (1993 - 2023).

Parameters	Average long-term parameters			
	In the region	agroclimatic regions of the region		
		I (northern part)	II (central part)	III (southern part)
Total precipitation, mm	290 – 340	344	325	292
Total active temperatures, °C	2 250 – 2 450	2 247	2 380	2 423
Hydrothermal coefficient (HTC)	1.0 – 1.4	1.2 – 1.4	1.1 – 1.3	1.0 – 1.2

Ryazan region is divided into 3 agroclimatic regions in terms of heat and moisture supply and soil types. The soil and climatic conditions in the north and south of the region differ significantly, which is due to the fact that the border between the forest and steppe zones of Russia passes through the territory of the region.

The northern, lower part of Ryazan region, which belongs to the first agroclimatic region (I), is mainly occupied by 3 administrative regions (Figure 1).



Fig. 1. Agroclimatic regions of Ryazan region.

The central agroclimatic zone (II) includes 12 districts, and the remaining 10 administrative units are located in the southern part of the region, on the territory of the third agroclimatic region (III).

Most of the soybean production (54.3 thousand hectares or 56.5%) is located in districts that belong to the III agroclimatic zone of Ryazan region, since this territory is characterized by the highest sum of active temperatures and more fertile soils (Figure 2).

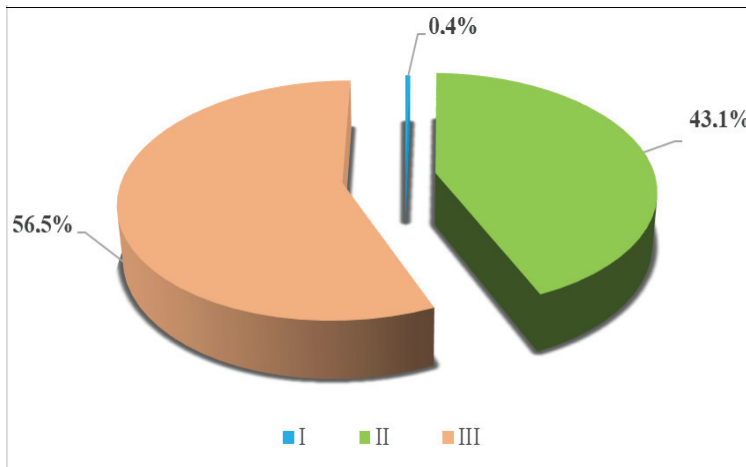


Fig. 2. Distribution of soybean sown areas by agroclimatic zones of Ryazan region in 2023, %.

With the emergence of new early maturing soybean varieties, its production is expanding in the central part of the region, gradually moving towards the northern borders of the region. In 2023, the area of soybean crops in the central regions amounted to more than 40 thousand hectares (43.1%). Agricultural enterprises located in the north of the region find it difficult to select soybean varieties that are guaranteed to ripen in conditions of this agroclimatic region.

The varietal diversity of soybeans available for cultivation makes it difficult for agricultural producers to choose, including within the boundaries of one region. The number of varieties cultivated in Ryazan region increases annually (Table 3).

Table 3. Dynamics of soybean varieties used in Ryazan region in 2019 - 2023.

Parameters	Year				
	2019	2020	2021	2022	2023
Total number of varieties, pcs.	20	26	31	40	50
Share of varieties of Russian selection, %	55.0	46.2	38.7	50.0	54.0
Share of sowing areas occupied by varieties of Russian selection, %	47.3	25.4	28.7	18.7	42.8
Share of sowing areas occupied by varieties recommended for the Central region (3)	20.2	15.4	27.5	23.8	31.9

A significant part of the soybean varieties grown in Ryazan region were bred for other regions of Russia, with soil and climatic conditions different from ours, and, first of all, for the Central Black Earth (5) and Far Eastern (12) regions. The share of areas occupied by soybean varieties recommended for cultivation in the more northern Central region (3), to which Ryazan region belongs, in the structure of sown areas ranges from 15.4% to 31.9%.

And what is also important in the context of import substitution - more than 50% of the soybean area in the region is occupied by varieties of foreign selection (Canada, Germany, France, Belarus). In 2022, this figure was more than 81.3%.

There is no information on the implementation of the varietal potential, biological characteristics and protein content of seeds of the modern soybean assortment, which is cultivated in the region and includes 50 varieties. When selecting soybean varieties, agricultural organizations cannot be sure of obtaining a high-quality harvest, and varieties that have shown good results in other soil and climatic conditions will be able to realize their potential in Ryazan region. Therefore, we conducted a comparative five-year analysis of the actual and potential yield (the average yield of varieties indicated in the state register of breeding achievements of the State Commission of the Russian Federation) (Figure 3).

The analysis of the presented data shows that the actual yield of soybeans directly depended on the cultivation area, and its growth from north to south was clearly traced. Thus, the actual yield in all areas related to the III agroclimatic zone of Ryazan region was more than 18 c/ha. The only exception was Shilovsky district, the northern part of which is located in zone II, where the range of yield variation was from 3.8 c/ha to 20.9 c/ha. The lowest indicators were noted in areas bordering the northern I agroclimatic region.

Thus, the varietal potential of soybeans was realized in farms in 12 districts of Ryazan region, where the actual yield exceeded the potential, which indicates the optimal selection of varieties. In the II agroclimatic zone, an excess of 1.8 - 37.5% was noted in 7 districts, and in zone III, respectively, by 1.1 - 15.9% in 5 districts.

At the same time, in 50% of the regional districts, optimization of the assortment is necessary, since the potential yield of soybeans in them was higher than the actual one by 5.4 - 57.1%. The greatest variation was noted in farms of the I and II agroclimatic regions of Ryazan region.

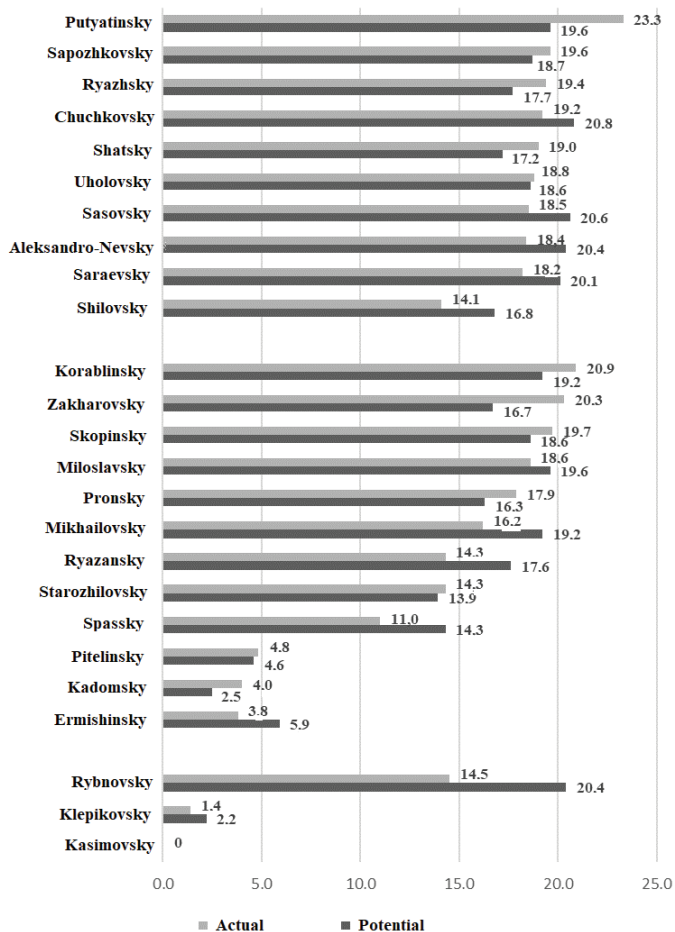


Fig. 3. Actual and potential soybean yields by districts of Ryazan region on average for 2019–2023, c/ha.

In the coming years, the growth of soybean production in the Central region of the Russian Federation will continue, as the demand for oilseeds is high. It is possible to increase soybean production not only through extensive measures (increase in sown areas), but also through intensification of production (implementation of varietal potential). Soybeans have a high degree of adaptability to various soil and climatic conditions, so the correct assortment will increase the volume of production in areas with a moderate climate. Therefore, in Ryazan region, the central regions located in the II agroclimatic zone will have the greatest potential.

4 Conclusion

The results of studying the conditions for growing promising Russian soybean varieties, which allow obtaining the optimal combination of yield and seed quality of the crop in specific soil and climatic conditions, are contradictory and cannot always be extrapolated to production crops.

It should also be taken into account that individual agricultural practices in conditions of a particular region are not efficient enough to realize the varietal potential of soybeans.

In connection with the introduction of new highly productive soybean varieties into production, innovations in agricultural engineering, and the expansion of the range of agrochemicals, it is necessary to study the problem of obtaining stable soybean yields in the regional context [3].

It should be noted that the quality of raw materials and their suitability for use in food production largely depend on varietal characteristics of soybeans, which is currently relevant for attracting Russian consumers [7].

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