Soybean: research and development in Amur Region, Russia

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Abstract. Soybean and its products are widely distributed around the world. This agricultural crop occupies a certain place in populous countries where there is a shortage of protein in the daily diet and food products in general. Russia's historical situation has given rise to the large-scale development of soybean production in the Amur Region. Therefore, a Soybean Institute was founded in the region, engaged in research in breeding, genetics, microbiology, biotechnology, seed production, soybean protection, and soybean technologies cultivation and processing. The Institute aims to breed soybean varieties to increase yields in the Russian Far East regions' climatic conditions. In recent years, the Institute has been developing new varieties that meet the requirements of the climate and consumers' needs. The article shows the Soy Institute's latest achievements and the development of soybean production in the Amur Region.

1. Introduction

Soy cultivation has a long past in Russia. Naturally, historical factors led to its introduction into the Amur Region from China. Under the guidance of agronomist Rubinsky, there were attempts to introduce foreign varieties of soy. On a small experimental plot, high-yielding legumes were grown. The unequivocal conclusion that foreign soybean varieties do not mature in the Amur region gave an impetus to analytical breeding. Therefore, the most complicated breeding experiments were carried out in the open field to obtain local stable varieties [1,2].

The settlers tried to grow varieties of grain and other crops brought from their homeland, but in the region's climate, they were affected by diseases and pests, winter crops were frozen in winter. To solve the region's food independence, the Russian Academy of Sciences sent a soil-botanical team to the Amur Region under the leadership of soil scientist Professor Nikolai Prokhorov. As part of the Amur scientific expedition, the detachment began organizing a pilot project on the Amur. In 1908, the first experimental crop rotation was placed. Nowadays, the fields of the All-Russian Research Institute of Soybeans' breeding and seed production laboratories are located on this historical site [1,3,4].

The Russian Far East was in an important position as a food production base and the political and military key points of large-scale development in the Soviet era. With the collapse of the Soviet Union, the central government's support has drastically declined, and the economic slowdown has deepened as agriculture, and industrial production declined sharply, and the social decrease of the population progressed rapidly. From the viewpoint of geopolitical and socioeconomic aspects, redevelopment in the Far East region is the Russian Federation Government priority [5].

The Amur Region on the Far East of Russia occupies a leading place in agricultural product production. The main crops grown in this area are soybean and cereal crops. Soybean is one of the priorities and a highly profitable crop in the Amur region. The soil and climatic conditions of the region
favorably influence soybean growth and development [6].

The article shows the development of soybean production in the Amur Region of the Far East of Russia, where the Soybean Institute is located. The Institute is one of the main institutes in the Far East in which the breeding of new varieties of soybeans is carried out. The article is also aimed at revealing the latest results and achievements of the institute.

2. Materials and methods

2.1. Data obtaining
The data were taken from the Russian State Statistical Services. The data on soybean production was taken from the Russian Federal State Statistics Service. The data on soybean varieties was taken from the State Register of Breeding Achievements.

Analysis of the data was processed by using R software. R software allows expanding the visualization of graphical data to present the analyzed information better. The ggplot packages of R Software were used to visualize graphical data. Map of Region was drawn by using QGIS free software.

2.2. Amur Region
The Amur Region on the Far East of Russia occupies a leading place in crop production. The main crops are soybean and cereal. Soybean is one of the highest profitable crops in the Amur Region. The agricultural sector is positioned as a leading sector of the local economy. The soil and climatic conditions of the region favorably influence soybean growth and development. Three major soybean growing areas can be determined—northern, central, and southern. The southern part of the region, the fertile, black-earth lowland of the Zeya-Bureya Plain, is now mainly under cultivation [7]. The Amur River provides a natural border with China to the south. The region borders the Republic of Sakha in the north, Chita Region in the west, and the Jewish Autonomous Region and the Khabarovskii Region in the east [6].
2.3. Institute of Soybean
The All-Russian Scientific Research Institute of Soybean is located in Blagoveshchensk city of the Amur region, Russia. The Institute of Soybeans is a state scientific institution of the Russian Federation that researches breeding, genetics, microbiology, biotechnology, seed production, soybean protection, and soybean technologies cultivation and processing. Its structure includes seven laboratories and two groups (figure 2). The Institute's researchers carry out fundamental research on the study of soybean genetic resources, the processes of symbiotic nitrogen fixation, and photosynthetic activity of soybean crops. The institute conducts biotechnological methods to create a transgenic soybean plant and obtain interspecific somatic hybrids [7].

![Figure 2. Research and development structure of the All-Russian Research Institute of Soybean in November 2020 year.](image)

3. Results and discussion
3.1. Soybean research in the Institute
The All-Russian Research Institute of Soybean was established in 1968 based on the Amur State Agricultural Experimental Station. However, its history goes back a long way. In 1908, an experimental research base was founded in the Amur Region by the soil-botanical detachment of the Russian Academy of Sciences' complex expedition under the guidance of soil scientist Professor Nikolai Ivanovich Prokhorov. The beginning of the work was laid in the selection of varieties adapted to the conditions of the Region. After selecting wild varieties that matured well in cold regions, they were crossed with cultivated varieties. Thus, the first local Amur varieties were created [1].

At the moment, scientists of the Institute have created more than 80 highly productive, cold-resistant, weakly reacting to the length of daylight soybean varieties. Currently, soybean varieties created in the All-Russian Scientific Research Institute of Soybeans are divided by zones and three federal districts of the Russian Federation: Middle Volga, East Siberian, and Far Eastern. There is continuous replenishment and using breeding and genetic studies for the gene pool of wild and cultivated soybean, created according to each district's economically valuable and climate features. There are various soybean varieties in the Institute of Soybeans and conducting their primary seed production using individual family selection with a two-year progeny assessment [7,8].

For the 2020 year, the Russian Federation State Register of Plant Breeding registered for use includes 28 varieties of soybean from the Institute with a growing season from 85-90 days (extra-early maturing) to 120-130 days (late-maturing) with a potential yield from 2.0 to 4.2 t/ha. In the 2020 year, Charodeika and Topaz soybean varieties were approved with early maturity features. New varieties such as Zhuravushka, Kruzhevnitsa and Nevesta were included in the State Register in 2018. In 2019, the variety of Sentiabrinka, Zolushka and Statnaia were registered as high protein content varieties (figure 3) [8].

The soybean variety Kruzhevnitsa was included in the State Register of Breeding Achievements in the 2018 year. This variety is used in production and further application in the breeding process as a marker variety based on multi leaves (5-9 leaves, instead of 3 leaves) and felt pubescence, which is resistance to limited thermal resources. There is no such variety in the Russian soybean collection that has such features. The creation of highly productive varieties of the new generation, capable of maturing in conditions with limited thermal resources, will allow soybean cultivation in Russia's northern
In the future, this will allow expanding the cultivated area to the northern areas and using more land resources [8].

Currently, most of the soybean crops of the Amur Region are occupied by varieties of the Institute of Soybean, more than 60% of the total sown area in the region. The most popular varieties are Lidia, Dauria, Umka, Alena. Sowing acreage of the Institute’s soybean varieties is gradually increasing [9].

The Institute continues the long-term international cooperation with China and Japan. The main direction of cooperation is joint research work on breeding and ecological-geographical testing, mineral nutrition, and soybeans protection from harmful events. In the province of Heilongjiang (China) with the Heihei branch of the Heilongjiang Academy of Agricultural Sciences and Beijing with the Institute of Plant Cultivation of the Chinese Academy of Agricultural Sciences, an ecological test of soybean varieties of the All-Russian Soybean Research Institute is being conducted for scientific purposes. In the laboratories of soybean breeding and plant physiology, the All-Russian Soybean Research Institute is studying 15 Chinese breeding varieties.

Since 2017, cooperation between the Institute of soybean and Japan has been carried out to study soybean biology to increase its protein content and obtain a high yield. In 2019, the second stage of cooperation with Niigata University, Japan, was launched to study the effect of fertilizers on the intake of nutrients in seeds and the yield of soybeans, as well as the spread of viral diseases of soybeans.
3.2. Soybean production in the Amur Region

The Amur Region on the Far East of Russia occupies a leading place in agricultural product production. Soybean is one of the leading crops in the Amur Region. Over 30% of the total area of soybean crops in the country is located on the Amur Region's territory, which has increased by 150% over the past five years, and the average yield in the region has increased to 1.4 tons per hectare [10].

Figure 4 shows the production of soybeans in the Amur Region, where a massive increase in sowing areas is seen from the early 2000s to 2019. Due to the growth in demand for soybeans, there was an increase in acreage. In 2019, the sown area of soybeans amounted to 870 thousand hectares. In the same year, the production volume amounted to 910 thousand tons, which indicates a low average yield in the region [11]. When in 2017, the volume of production amounted to 1 million 370 thousand tons [11]. In 2016 and 2019, the region faced flooding caused by record daily rainfall [12]. In general, the average yield of 1.4 tons per hectare is low throughout the Amur Region, although in some areas, yields are 1.8 tons per hectare. This is well below the world's leading average soybean production of 2.7–2.9 tons per hectare [12].

Low yields are characterized by climatic difficulties such as waterlogging and early cold and snow during harvesting. Waterlogging is one of the main issues in the region and the problem of the challenging operation of machinery in these conditions [6].

4. Conclusion

The increase in crop areas is characterized by an increase in demand for soybeans in Russia’s Far Eastern Regions. The expansion of arable land is also stimulated by breeding new varieties, resistant to limited thermal resources, by The Institute of Soybean. This feature is necessary for growing soybeans in the northern part of the regions and cold climates. One of the main goals of the institute is to develop varieties for northern territories with unpredictable weather. Therefore, the Soybean Institute is the most important center for developing soybean production in the Amur Region, in the Far East, and Russia.
The Institute has established new zoned soybean varieties and optimal sowing dates, refined seeding rates at the first and subsequent stages of seed production, selected a soil treatment system for soil and climatic conditions, developed methods for using integrated means of biologization and chemicalization, ensuring stable production of crop seeds with relatively low energy and resource costs.

Further development of scientific support for seed production of soybean aims to accelerate the introduction of new varieties and reduce costs in the production of original seeds. For a faster introduction of new varieties, the possibility of mass selection is being studied. The implementation of the above techniques ensures sustainable variety renewal, guaranteed supply of farms of the Far Eastern and Siberian regions with high-quality seeds, and strict selection in primary seed production contributes to preserving economically valuable qualities.

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