Research Progress on Soybean Cultivation and Breeding in the Far East Region of Russia

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Abstract: This paper summarized the recent advances of soybean cultivation and breeding in the leading Russian Far East Institute in agriculture and biology. One hand, some soybean varieties in the far east region of Russia were introduced, which were bred by the traditional line selection and crossbreeding and characterized by high yield, high disease resistance, wide adaptability, good quality and suitable mature period. On the other hand, methods and application situation of biological techniques and molecular techniques in soybean breeding were reviewed, and discussed their development prospects.

Key words: Soybean; Far East region of Russia; Conventional breeding; Agri-biotechnology

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远东地区大豆栽培及育种研究进展

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摘要: 本文对俄罗斯远东研究所在大豆栽培及育种方面的研究进展进行了总结。一方面介绍了一些通过传统育种方法选育的俄罗斯远东地区的主栽大豆品种,这些品种具有高产、高抗病性、广适、优质及熟期适宜的特点;另一方面对大豆育种中的生物及分子技术方法和应用情况进行了综述,并探讨了其发展前景。

关键词: 大豆; 远东地区; 传统育种; 农业生物技术

Depending on richfarming land resources and favorable mechanization condition, the Far East region of Russia is the primary soybean production area in Russia. Many farms in this region consider soybean production as the main form of the whole agricultural production. It is generally known that the monsoon climate condition and natural environment with sea coasts in the Far East region of Russia are suitable for soybean cultivation. In particular, long frost-free period and appropriate photoperiod-temperature accumulation make it possible for soybean varieties of different mature periods to be grown in the most of this region. At present, the total area for cultivating soybean is 900,000 hectares, which can yield more than one million ton.

However, soybean production did not increase significantly in recent years. It is because that weather patterns become more volatile and extreme weather events become more frequent over the past years. Extremely high temperature and humidity resulted in serious occurrence of pest and disease with great economic losses to soybean production. In order to reduce the impact of extreme weather events and increase soybean production, a lot of work has been carried out in the Far Eastern institutions, especially in the All-Russia Scientific Research Institute of Soybean, Primorsky Scientific Research Institute of Agriculture and the Far Eastern Scientific Research Institute of Agriculture.

1 Research work in the Far Eastern Scientific Research Institute of Agriculture

The Far Eastern Scientific Research Institute of Agriculture has made progress in the selection and crossing method of soybean parents with different interval periods in both pre- and post-flowering. This method has been used to develop new soybean varieties yielding about 4.0 $t \cdot ha^{-1}$ such as Sonata, Harmony, Lidia and Lazurnaya. What's more, these new varieties can extend soybean-producing areas to the 56th parallel of north latitude in Russia[1]. In addition, experimental mutagenesis study has been carried out on the basis of the establishment of soybean gene pool. Soybean popu-

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lations with purpose characters were developed by a combined method of mutation and hybridization. Through hybridization selection high-yielding soybean varieties Marinata and Ivan Karamanov were bred.

2 Research work in the All-Russia Scientific Research Institute of Soybean

The All-Russia Scientific Research Institute of Soybean has done a lot to study rhizobia-soybean symbiotic nitrogen-fixation, a microbiological process which converts atmospheric nitrogen into a plant-usable form and offers an economically attractive and ecologically sound means of reducing external N inputs and improving internal N resources. On average, symbiotic systems of soybean and rhizobia provide 57.4% of the total amount of nitrogen assimilation. Some studies show that this index can be increased to 80% by agricultural technology and methods. Other studies have found that phosphorus deficiency affected significantly nodule development and nitrogen-fixation process when soybean plants formed sufficient nodule[2]. With exception of native rhizobia for soybean in the Far East region of Russia, the application of soybean rhizobia inoculum increases the yield by 0.16 - 0.20 $t \cdot ha^{-1}$. The nitrogen-fixation process is so important that it may be able to associate rhizobia with other non-leguminous plants in future.

The All-Russia Scientific Research Institute of Soybean has carried out research in the field of gene introgression from typical wild soybeans to cultivated soybeans. Wild soybean germplasm as the important genetic resources can introduce beneficial traits into soybean breeding program to help better withstand the impacts of climate change. The beneficial traits of wild soybeans is mainly referred to resistance to major diseases and insects, tolerance of abiotic stresses, early maturity, insensitivity to the lighting condition and seed protein content as high as 46%. Some soybean varieties with characters of cold tolerance, high yield and good quality had been successfully bred, such as October 70, Aurora and Rassvet. The efficient introduction of these traits from wild soybean is a prerequisite for realizing a breakthrough progress in soybean breeding[3].

3 Research work in Primorsky Scientific Research Institute of Agriculture

Primorsky Scientific Research Institute of Agriculture has conducted many researches and published some papers, which involve excellent germplasm selection, high yield cultivation and breeding, biotechnology, agricultural chemistry, agricultural economics and other soybean-related works. In the process of soybean germplasm selection, a deep agrobiological study of parent materials should be carried out first on the basis of ecological adaptability and high stability of agronomic characters. Ecological and geographic difference of the parent materials, which were used for crossbreeding, can be identified in the next generations. It is generally known that owing to the difference of geographic ecology in the parent materials, there exists the distinct differentiation of bearing period. T-Wo-Fu with elite characters, which was used as a donor to obtain a early-maturing variety Primorskaya 13, was developed by the use of soybean germplasm selection[4]. In addition, the selection principle of parents in soybean crossbreeding procedure was determined. The largest heterosis can be observed in the cross combination of parents with maximum differences in main biological and economic characteristics.

Primorsky Scientific Research Institute of Agriculturealso studied many selection methods of parents. The correlation coefficients were calculated for identifying the most appropriate methods related to all the studied characteristics. The results of this research showed that on the variation of the progenies, the progenies materials had a trend that is different from female parent greatly, but similar to male parent. Rather, the elite characteristics of the progenies come more from female parent than from male parent. The most correlation between parents and progenies can be observed in 25% individual selection. In addition, soybean populations with purpose characters were developed by a method combined mutation with hybridization. A combined method of the parent selection and the following physical mutation (γ-irradiation Co^{60}) was studied and presented the combined advantage of crossbreeding and physical mutagenesis.

Fungal disease of soybean is one of the most serious diseases in the Far East region of Russia, and is also one of the most primary reasons that cause yield loss and quality reduction. The main diseases of soybean in the Far East region of Russia include frogeye leaf spot, brown streak, downy mildew and root rot. The investigating and evaluating system of soybean diseases resistance was established by Primorsky Scientific Research Institute of Agriculture. Proper method for evaluating resistance through artificial disease inoculations in fields allowed breeders to select and utilize resistant germplasm resources, which are the important founda-

tion for breeding resistance varieties. The identification of disease resistance showed that early-maturing soybean varieties were the most susceptible. What's more, a lot of improved soybean varieties of resistance to fungal disease with high yield and good qualities had been developed, such as Venera (middle maturity), Primorskaya 301 (middle-late maturity) and Primorskaya 69 (middle-late maturity).

Though the conventional breeding has made remarkable achievements in the genetic improvement of soybean, it does not satisfy the current production demand of fine soybean varieties, which are resistant to virulent pests and diseases and adapted to changing environments. Advances in biotechnology, especially in the area of regeneration techniques and molecular biology provide some important tools for breeding new and more productive varieties, widening genetic basis and increasing genetic diversity of soybean in the Far East region of Russia.

Regeneration systems of local varieties and their somaclonal lines *via* embryogenesis and organogenesis have been adopted and applied successfully for more than 20 years by Agri-Biotechnology Laboratory of Primorsky Scientific Research Institute of Agriculture (PrimSRIA). Using the method of cell and tissue culture during embryogenesis, PrimSRIA bred Primorskaya 81, which was the first soybean variety in Russia *via* biotechnology breeding and recommended for large-scale cultivation in 2004[5]. To compare the differences of original and regenerated plants, researchers in PrimSRIA and the Biology-Soil Institute of Russian Academy of Sciences (BSI RAS) of the Far Eastern Branch of RAS have carried out the analysis of genetic variability of soybean varieties and somaclones using inter-micro satellite sequence repeat (ISSR) markers. The dendrogram based on the SSR analysis clustered all materials into corresponding groups and showed a complicated genetic variation pattern[6-8].

With the development of agricultural biotechnology, genetic modified organisms (GMO) camfluding forth successively, such as transgenic potato, soybean, maize and other crops, and were applied in many fields to benefit people. Many traits were introduced into GMO, which including nutritional quality, resistance to herbicides, diseases, and insects, and tolerance to drought and cold. What's more, with the advances of transformation methods and genome sequencing, the number of transgenic crops authorized for release was increased rapidly[9]. Researchers in PrimSRIA developed *Agrobacterium*-mediated genetic transformation for soybean and obtained transgenic plants in 2010, co-funded by Russian Fund of Fundamental Researches and the All-Russia Scientific Research Institute of Agricultural Biotechnology (Moscow). PCR analysis of the total DNA extracted from transgenic plants has shown that the target gene had been integrated into the soybean genome. Kanamycin-resistance segregation in transgenic plants showed that the most transgenic lines were in single gene inheritance[10].

4 Conclusion

As reviewed above, the institutes in the Far East region of Russia have carried out a lot of research works on soybean and made important contributions to soybean production in this region. In the future, the Far East region of Russia still need to do more work for the further research and development of soybean.

References

[1] Chaika A K, Tilba V A, Sinegovskaya V T. Soybean cultivation technologies[M]. 2010: 46.

[2] Sinegovskaya V T. Soybean sowings in priamurye, as photo-synthetic systems[J]. Blagoveshchensk, 2005: 100.

[3] Ala A Y, Tilba V A. Genetic methods of selection of *G. max* (L.) Merr. X *G. soja*. Blagoveshchensk: Zeya Publishing, 2005: 123.

[4] Vashchenko A P, Mudrik N V, Fisenko P P. Soybean in the Far East[M]. Vladivostok, Dalnauka, 2010: 435.

[5] Efremova O S. Usage of soybean mutants in regeneration process and soybean selection. Modern research in biology[Electronic Resource]. I All-Russia Scientific Conference. 2012: 25-27.

[6] Kozyrenko M M, Fisenko P P, Artyukova Ye. V. Analysis of genetic variability of varieties and somaclonal lines of soybean [*Glycine max* (L.) Merr.] using ISSR[J]. Biotechnology, 2007, 1: 3-13.

[7] Fisenko P P, Kozyrenko M M, Artyukova Y V, et al. Genetic analysis of varieties and somaclonal lines of soybean using method ISSR[J]. Oil Crops: Scientific-technical Bulletin of All-Russia Scientific Research Institute of Oil Crops, 2009, 1(140): 84-90.

[8] Fisenko P P, Babikova A V, EFremova O S. Effect of different kinds of ionizing radiation and cultivation duration upon the level of genetic variability of soybean somaclones[J]. Oil Crops: Scientific-technical Bulletin ARSRIOC. 2010, 1(142-143): 98-104.

[9] Kharchenko P N. Biotechnology in plant growing[J]. Bulletin of RAAS, 2011, 1: 30-32.

[10] Efremova O S. Development of soybean transgenic plants[*Glycine max* (L.) Merr.] using method of agro-bacterial transformation. XIV All-Russia Youth School-Conference on Actual Problems of Chemistry and Biology (Electronic Resource). Marine Experimental Station of the Pacific Institute of Bio-organic Chemistry, Vladivostok, 2012: 11-18.