

Import Substitution of Leguminous Crops as A Stimulus for the Development of Russian Plant Breeding

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Received: August 16, 2018; Published: October 23, 2018

Abstract

The authors present a review of the plant breeding of leguminous crops at Omsk State Agrarian University. A correspondence between the biology of the varieties and local conditions is essential to ensure a high productivity and quality of the seeds of leguminous crops in the southern forest-steppe of Western Siberia. Along with the implementation process of the research programmed, varieties of beans (*Phaseolus vulgaris*) for fresh consumption have been created for the first time, whereas the breeding of beans for dry consumption has been resumed in the region after a long interval of time. In addition, the university has been breeding the following crops: peas (*Pisum sativum.*), chickpeas (*Cicer arietinum*), broad beans (*Vicia faba*), and lupins (*Lupinus*). Results confirm that the introduction of new, adaptive varieties should lay the foundation for an increase in the import-substituting agricultural production of leguminous crops. Also, scientific research has shown that in the peculiar conditions of the southern forest-steppe of Western Siberia the following leguminous crops can be effectively cultivated for alimentary purposes: beans for fresh and dry consumption, chickpeas, peas, and broad beans.

Keywords: Variety, Beans; Broad Beans and Peas; Chickpeas; Hybridisation; Variety Testing; Yielding Capacity; Productivity; Producibility

Introduction

The increase of the Siberian land productivity represent an issue which requires particular attention as far as both science and practice are concerned. The varied range of natural climatic conditions, their harshness and variability according to time and space can cause exceptionally complex issues for agriculture. The peculiarities of the Western Siberian harsh continental climate consist in the fact that, according to the distribution and intensity of meteorological factor manifestation over the years and throughout the vegetation period, a significant instability can be observed, while the topsoil is characterised by variability and marked complexity. For this reason, a crucial role in the increase of the Siberian land productivity is played by variety, conceived as a dynamic biological system capable of implementing its genotype potential under specific technological conditions. For agricultural production – under both favourable and extreme meteorological conditions – varieties

with high potential productivity, environmental sustainability, as well as distinct production quality are preferable. Studies on the plant breeding of leguminous crops in Siberia have been traditionally focusing on peas. To this day cultures such as chickpeas, beans, lentils, broad beans and peavines have almost no economic significance in the region, play a purely experimental character, and are cultivated on small surfaces, basically as horticultural crops [1-3].

Leguminous crops represent important food products due to their high content of easily digestible proteins, vitamins, biologically active substances, and mineral salts. It is undoubted that anytime soon human nutrition will become more and more complete thanks to a wider use of products rich in vegetable proteins. Analysts agree that in the 21st century the process of intensive biologisation of agriculture and horticulture will go on thanks to a decrease in the technogenic impact on the biosphere, which will

be implemented by minimising soil treatment and reducing the application of chemicals. For this reason, a general increase of areas cultivated with leguminous crops, a diversification of their varieties, as well as the introduction of new, non-traditional cultures are necessary. An increase in the diversification and cultivation area of such crops can occur in Siberia only by means of plant breeding and diffusion of new, adaptive varieties.

Materials and Methods

The varietal research and creation of source material of leguminous crops was carried out at Omsk State Agrarian University (hereafter "Omsk SAU") from 1999 to 2017 on the small experimental field (work-study unit) of the Department of Agronomics, Plant Breeding and Seed Research in accordance with the generally accepted agronomical practices for the cultivation of leguminous crops in the southern forest-steppe of Western Siberia. The material at study annually consisted in the following samples, hybrids and breeding lines included in the collection: beans (*Phaseolus vulgaris*) for fresh and dry consumption, peas (*Pisum sativum*), broad beans (*Vicia faba*), and chickpeas (*Cicer arietinum*).

The trials were planted in meadow-chernozem soil, previously cultivated with spring wheat.

Over the years of the research, the meteorological conditions have been changing as regards the quantity and distribution of precipitations and the temperature regime, which allowed a qualitative evaluation of the samples, hybrids and breeding lines of the collection in relation to their basic agronomic characteristics. The study of the collection material has been carried out following the methodology of the All-Russian Institute of Plant Engineering (hereafter "VIR": Vserossiyskiy institute rastenievodstva; Leningrad, 1975) and the methodology of the statal variety testing of agricultural plants (Moscow, 1989). The field evaluation of infectious diseases has been carried out on the basis of a scale in accordance with the classifier (VIR, 1984). The tuber formation capacity has been established during the flowering and initial legume formation phases of the plant according to quantity, dimension and positioning of the tubers following G.S. Posypanova's methodology (1991). The chemical composition of seeds and fresh legumes has been carried out during the phase of technical maturity at the Omsk branch of the FSBI Federal Centre for the Safety and Quality Evaluation of Seeds and Processed Products [2]. Mathematical processing has been carried out following B.A. Dospikhov (1985).

Research Outcomes and Discussion

The plant breeding of leguminous crops at Omsk SAU started with bean cultures. In 1997, under the supervision of the Department of Plant Breeding, Genetics and Plant Physiology assistant professor T.S. Ryzhkova, the first collection samples of beans (10 items) were received from the VIR. Since 1998 the activities regarding the study of the collection and the creation of source material of leguminous crops have been carried out at the laboratory of plant breeding and seed research of field cultures by the Department professor N.G. Kazydub. In 2017 the collection of beans amounted to about 200 samples from different countries.

The aim of the research consists in an overall study of the biological peculiarities of the culture and its varietal diversification, as well as in the isolation from the collection of the most promising samples according to the main agronomic characteristics and recommendations for the plant breeding process plan in the conditions of the southern forest-steppe of Western Siberia.

More than 150 samples of beans undergo varietal study yearly; the plant breeding activity takes into consideration their productivity, maturing rate, resistance to diseases and pests, suitability for mechanical cultivation, enhanced intensity of nitrogen fixation, as well as the qualities of fresh legumes and the high content of proteins, micro- and macroelements in the seeds. As a result of our multi-year research, a new model of bean variety for fresh and dry consumption has been elaborated and proposed for the conditions of the southern forest-steppe of Western Siberia, taking into consideration the limiting factors of temperature and humidity, and in particular their distribution among the plant development phases. While carrying out the scientific research programme, varieties of beans for fresh consumption in the conditions of the southern forest-steppe of Western Siberia have been created for the first time, whereas the breeding of beans for dry consumption has been resumed in the region after a long interval of time.

The first varieties created include: beans for fresh consumption *Pamyati Ryzhkovoy* (In memory of Ryzhkova), *Zoloto Sibiri* (Siberian gold), *Marusya* and *Sibiryachka* (Siberian girl), and beans for dry consumption *Luker'ya*, *Olivkovaya* (Olivaceous), *Omskaya yubileynaya* (Omsk anniversary), *Sibakovskaya 100* (Siberian academy 100) and *Omichka* (Omsk girl) (creators include N.G. Kazydub, N.V. Khramtsova, A.P. Kling, S.P. Kuz'mina, T.V. Marakaeva, M.M. Korobeynikova and others). The peculiarities of the new

bean varieties bred at Omsk SAU consist in high-yielding capacity of seeds and fresh legumes, good content of proteins in the seeds, good cooking properties, suitability for canning and freezing, resistance to anthracnose, and high lower bean insertion, as well as suitability for mechanical harvest in the case of cultivation in industrial production. The seeds of the varieties bred at Omsk SAU have a potential yielding capacity of 3.1 - 4.9 t/ha. The results of the study on the collection and on the new locally-adapted varieties confirm the promising outlook of bean cultivation in the conditions of the southern forest-steppe of Western Siberia, whereas the obtained valuable source material of common beans is being effectively used in the plant breeding process at the Department of Agronomics, Plant Breeding and Seed Research and at the laboratory of plant breeding and seed research of field culture named after S.I. Leont'ev [4,5].

In addition, technologies for the line production of fresh legumes in the southern forest-steppe of Western Siberia are being elaborated.

Considering the entrance of Russia into the WTO, the evaluation of the competitiveness of Russian varieties as compared to foreign analogues has become very important. The aim of creating a new bean variety for the conditions of the southern forest-steppe of Western Siberia has been accomplished. The obtained data show that the bean varieties bred at Omsk SAU are not inferior to foreign ones as regards their yielding capacity and quality of seeds and legumes. The research has been carried out under the supervision of the Omsk Region Ministry of Agriculture and Food and the Russian Federation Ministry of Agriculture. We consider the necessity to devote more attention to the study and development of varietal agronomical practices of area-specific promising varieties of common beans to be a crucial issue.

Since 2004 research on the collection of broad beans imported from the All-Russian Research Institute for the Plant Breeding and Seed-research of Vegetable Cultures (hereafter "VNISSOK": Vserossiyskiy nauchno-issledovatel'skiy institut selektsii i semenovodstva ovoschnykh kul'tur) has been carried out. At the present time the collection includes more than 30 samples from Russia, Germany, Poland and other countries. The undertaken comparative evaluation of the collection samples concerns their biological characteristics, yielding capacity and its elements, maturation period, resistance to diseases and pests, suitability for mechanical cultivation, symbiotic activity, and seed quality. The broad bean samples, classified on the basis of their set of agronomic character-

istics, have been included in the hybridisation and plant breeding process at Omsk SAU. The obtained material has been undergoing an overall study and breeding for the conditions of the southern forest-steppe of Omsk Region [6].

The research on the collection of peas and the creation of source material for plant breeding for the conditions of Omsk Region began in 2008. At first the study concerned collection samples from the VNISSOK, but henceforth varieties from Poland, Germany and China have been included. In 2016 - 2017 the collection was enriched by samples from the VIR. In 2017 a total amount of more than 70 samples included in the collection underwent research. The aim of the research consists in the economic and biological evaluation of several varieties of peas, the identification of the sources of agronomic characteristics, and the creation of source material for the plant breeding of peas for the southern forest-steppe of Western Siberia. The collection of peas has been studied according to their yielding capacity and its elements, duration of interstage and vegetation periods, resistance to diseases and pests, suitability for mechanical cultivation, symbiotic activity, seed quality, taste characteristics, and suitability for canning and freezing. The identified sources of the agronomic characteristics included in hybridisation and the obtained hybrid flocks have been studied on the experimental field of Omsk SAU [7].

In 2011, under the supervision of S.P. Kuz'mina, assistant professor at the Department of Plant Breeding, Genetics and Plant Physiology, research on the collection of chickpeas, consisting of 12 samples obtained from the VIR, began. Chickpeas, in spite of their positive characteristics, are not very diffused in Omsk Region due to the absence of varieties adapted to the local conditions. For this reason, the overall study of chickpea samples and the identification of the sources of agronomic characteristics are crucial in order to create new varieties suitable for cultivation in Western Siberia. The efforts of the plant breeders have been mainly concerned with fast maturing rate, maturation simultaneity, productivity, resistance to diseases and pests, suitability for mechanical cultivation, and presence of proteins, micro- and macroelements in the seeds. In 2012 the chickpea collection was enriched by somaclones from the Siberian Research Institute of Feedstuff (hereafter "SibNII kormov": Sibirskiy nauchno-issledovatel'skiy institut kormov) of Novosibirsk. At the present time, the collection includes about 70 samples and breed lines of chickpeas at study. Original hybrid material with a complex set of agronomic characteristics has been created, and is presently at different breeding stages [8].

In 2016 the collection of leguminous crops at Omsk SAU was enriched with new, promising cultures: lupins and lentils (collection samples obtained from the VIR).

At the present time, the lupin collection consists of 60 samples of 8 different types: narrowleaf lupin (*Lupinus angustifolius*), yellow lupin (*Lupinus luteus*), white lupin (*Lupinus albus*), Andean lupin (*Lupinus mutabilis*), sandplain lupin (*Lupinus cosentinii*), blue lupin (*Lupinus pilosus*), bicolor lupin (*Lupinus bicolor*), and sky lupin (*Lupinus nanus*). The sample collection has been studied according to their biological characteristics, yielding capacity and its elements, maturation period, resistance to diseases and pests, suitability for mechanical cultivation, and symbiotic activity.

Over the last few years, at the laboratory of plant breeding and seed research of field cultures named after S.I. Leont'ev, research has been carried out within the framework of the state programme for the development of agriculture and the regulation of the agricultural production market of raw materials and food for 2016 - 2017 entitled "Development of fast-track methods for seed research on new varieties of beans for fresh (dry) consumption selected at Omsk SAU with the application of innovative technologies for the implementation of import substitution in the Russian agri-food market".

The scientific potential of plant breeding and seed research on leguminous crops is being investigated by Dr. Agr. Sci., professor and project supervisor N.G. Kazydub; Dr. Agr. Sci. and professor Yu.I. Ermokhin; Cand. Agr. Sci. and assistant professor S.P. Kuz'mina; Candidates Agr. Sci. T.V. Marakaeva, E.V. Bezuglova and M.A. Kolypova; postgraduates K.A. Dem'yanenko, N.A. Shitikov, N.N. Dvortsov, M.M. Korobeynikova and A.A. Burlakov; graduate students O.A. Kotsubenko, L.N. Lemeshova; E.V. Merzlyakova, E.A. Chernenko and others.

The research outcomes at the Department and scientific laboratory of Omsk SAU confirm the promising outlook of the integration between the university plant breeders and scientific institutions such as the VIR, the VNISSOK, the All-Russian Scientific Research Institute of Grain and Cereal Crops ("VNIIZ i krupyanykh kul'tur": Vserossiyskiy nauchno-issledovatel'skiy institut zerna i krupyanykh kul'tur), SibNII kormov, Saint Petersburg Electrotechnical University "LETI" ("ETU 'LETI'"), and others in dealing with genetic breeding tasks for the creation of highly adaptive varieties of leguminous crops.

Conclusions

Therefore, the outcomes of plant breeding confirm the accomplishment of the operative task of creating new varieties of beans. The obtained varieties match the model elaborated for the conditions of the southern forest-steppe of Western Siberia and are competitive in comparison to foreign analogues. It should be noticed that along with the creation of new varieties, in 2016 we obtained 1.5 t of top-quality seeds of beans for dry and fresh consumption. The outlined results confirm that the introduction of new, adaptive varieties should lay the foundation for an increase in the implementation of the import-substituting agricultural production of leguminous crops. Moreover, on the basis of scientific research it has been established that in the conditions of the southern forest-steppe of Western Siberia the following leguminous crops can be effectively cultivated for alimentary purposes: beans for fresh and dry consumption, chickpeas, peas, and broad beans.

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Volume 2 Issue 11 November 2018

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