Creating new varieties of vegetable peas (Pisum sativum L.) using multicomponent crossings

E P Pronina¹, V A Ushakov¹, A A Antoshkin¹, I P Kotlyar¹, I M Kaygorodova¹, F B Musaev², A V Soldatenko² and M Sh Gaplaev³

¹ Laboratory for selection and seed production of vegetable legumes, Federal State Budgetary Scientific Institution Federal Scientific Center for Vegetable Production, Odintsovo district of Moscow region, Russia
² Laboratory Analytical and Testing Center, Federal State Budgetary Scientific Institution Federal Scientific Center for Vegetable Production, Odintsovo district of Moscow region, Russia
³ Chechen Research Institute of Agriculture, Grozny, Russia

E-mail: epronina@yandex.ru, goroh@vniissok.ru, aa_antoshkin@mail.ru, vniissok@mail.ru, musayev@bk.ru, chechniish@mail.ru

Abstract. Vegetable peas (Pisum sativum L.) is an important food product containing high balanced combination of protein-carbohydrate complex, biologically active and mineral substances. The need for canned green peas in our country is not satisfied due to our own production. With the increasing competitiveness of varieties, further study and use of the potential for intraspecific hybridization is necessary. To achieve breeding goals to increase the productivity of vegetable peas, to strengthen other traits, it is important to increase the recombination of gametes from several varieties, so complex crosses are becoming increasingly important. The aim of the study is to create the source material of the early and mid-ripening groups of ripening with new economically valuable traits and to produce highly productive canned peas. For the first time, using the method of complex crosses involving geographically distant and morphologically different forms, high-quality pea varieties of canned vegetable peas were created using different ripeness groups, with an optimal combination of productivity elements suitable for mechanized cultivation technologies. The created adaptive varieties of peas of intensive vegetable type with delayed polymerization of sugars and a high content of amylose fraction in starch are competitive with foreign analogues in productivity and taste: Gribovsky jubilee, Maxdon, Corsair, Triumph, Barin.

1. Introduction

Peas (Pisum sativum L.) is considered one of the oldest crops on the globe. His homeland is the northwestern regions of India, Afghanistan, and the Mediterranean. Currently, peas are cultivated everywhere. The largest areas under it are occupied in the countries of Western Europe, North America, and a number of Asian countries. Vegetable peas is one of the least time-consuming, and therefore cost-effective crops. The production of green peas can improve the efficiency of use of equipment and the overall productivity of processing enterprises, as it is an important type of the earliest raw materials for the canning industry. After threshing green peas, 10–20 t/ha of green mass remains, which is a high-protein livestock feed. In crop rotation, peas are the best precursor for other crops [1].
The central regions of the Russian Federation most fully meet the biological requirements of peas for heat, moisture, daylight hours. The relevance of its use lies in a balanced combination of taste, nutrition, healing and preventive properties. By caloric content, green peas surpass other vegetables by 1.5–2 times; It is rich in proteins, sugars, starch, contains fat. It contains many salts of potassium, calcium, magnesium, iron; as well as elements important for metabolism, preventing sclerotic phenomena, removing radionuclides from the body. Due to the high content of vitamins (B1, B2, B6, C, PP, provitamin A), alkaline salts, trace elements, peas, vegetable peas are recommended for the treatment of vitamin deficiency, kidney, liver diseases and is considered a dietary product, especially in the diet of children [2]. The main countries – exporters of canned green peas are: France, USA, Hungary, China, India, Italy, etc.

In our country, the production of canned peas does not fully meet the needs of the population and the bulk is imported from abroad. Russian breeders have created a large variety of high-quality vegetable peas. However, canned varieties are characterized by the uniformity of morphological characters and properties [3, 4]. There are 2–3 varieties of vegetable peas adaptive to different growing conditions in each ripeness group [5].

The State Register of Selection Achievements Allowed for Use in 2019 includes 188 varieties of vegetable peas, of which 43 are breeds of the Federal State Budget Scientific Institution of Federal Scientific and Educational Center (22.9 %). However, every year the number of foreign varieties in the State Register is increasing. This indicates the underutilization of the reserves of existing methods of domestic selection, and the inclusion of varieties in the register gives the right to foreign companies to sell their seeds in Russia [6].

With the increasing variety competitiveness, there appears further study and use of the potential for intraspecific hybridization is necessary. The use of complex crosses significantly expands the possibilities of combinational variability. It helps to involve several best zoned varieties and collection specimens in crosses [7]. The inclusion of grain pea varieties in crosses is rare due to the fact that the taste of green peas is reduced in hybrids.

In order to accelerate the selection process methods of biochemical and genetic identification of the initial selection material have been increasingly used: electrophoresis of storage proteins, RAPD analysis of DNA spectra, etc. [8, 9].

2. Methods and materials
Experimental studies were carried out on the basis of the Federal Scientific Research Center for Vegetable Production (Moscow Region, Odintsovo District) from 2009 to 2018. Most of the collection material was provided by the Federal Research Center All-Russian Institute of Plant Genetic Resources named after N.I. Vavilova ”, and also used its own breeding material from the collection of the Federal Center for Science and Technology, a total of 160 samples. Vegetable pea samples were studied by quantitative and qualitative characteristics. Complex crossings were carried out according to certain schemes and multiple individual selection.

The agrometeorological conditions during the years of the experiment did not always favor the cultivation of crops, which also allowed us to evaluate the stability of promising samples to adverse environmental factors. Basically, in the initial period of the growing season, the moisture reserves in the soil are sufficient for the development of vegetable pea plants.

The laying of field experiments, phenological observations, the description of morphological characteristics and the calculation of the yield was held according to the Methodological guidelines for testing vegetables and melons of the Federal State Budget Scientific Institution of Federal Scientific and Practical Research Center in 2018 [10].

Crosses are conducted according to certain schemes different in the target orientation, composition and number of parent components. The varieties were involved in hybridization, and with the expectation of maximum recombination and saturation of hybrids with economically valuable traits [11].
Various samples of vegetable peas were evaluated in accordance with the methodological instructions of the State Commission for variety testing of agricultural crops [12]. Statistical processing of experimental data was performed using the software package of applied statistics MS Excel and Statistica 6.0.

3. Results
The study of the intersortic polymorphism was conducted based on the selection and genetic assessment of the quantitative characteristics of vegetable pea samples (using RAPD analysis of DNA spectra, analysis of variance, correlation and diallel analysis). The maximum number of recombinations were stepwise, saturating, and multicomponent crossings were used; new sources of precocity, bean insemination, and lodging resistance have been obtained.

Hybridization was carried out according to different schemes. The order of involvement in complex crosses of parental varieties was regulated by the appearance of the most valuable traits.

Valuable source material was obtained for individual characters and their combination using complex crosses. Productivity transgression was manifested in schemes of the type: [(AhB xB) – [ABVh (GhD)] – [ABVGD] involving varieties with well-defined various elements of productivity.

An optimal combination of productivity elements, biochemical and taste qualities was obtained for adaptive varieties of the intensive type with delayed polymerization of sugars and a high content of amylose fraction in starch: Corsair, Barin, Hercules. This result was obtained using geographically distant and morphologically different forms. New varieties have a genetically limited number of productive nodes ensuring the friendly ripening of green peas. They differ in early maturity, surpass the old varieties in yield and quality of green peas, resistance to diseases and lodging, are characterized by the best ratio of unproductive and productive parts of the plant. According to the structure of plants, these are semi-dwarf varieties with the top arrangement of beans on shortened internodes, with two to three beans on each productive node. This can provide an even long conveyor of domestic raw materials to processing enterprises.

The listed characteristics inherent to new varieties indicate that selection in the Federal Center for Scientific and Technical Research is carried out in the direction of creating varieties of canned food that satisfy production requirements.

The Corsair variety was bred using the method of complex multicomponent crossings with an individual selection with the participation of the following varieties: ‘Quartella’, ‘Usatii 180–79’, ‘Rannii 301’ and ‘Rannii Gribovsky 11’. This is an early ripe (CATE – 710 °C) vegetable pea variety. The length of the stem is 55–65 cm, the height of the lower bean stem is 25–31 cm, the bean is 8–9 cm long, contains 7–9 seeds, slightly curved and spiky. The average number of beans per plant is 6–10 pieces. Productivity – 6.5–7.0 t/ha. Green peas in technical ripeness have friendly ripening and excellent taste. Seeds are green, 1000 pieces weight 160–170. The State Commission of the Russian Federation for the Testing and Protection of Breeding Achievements FSBI introduced the Corsair variety in the State Register of Breeding Achievements. They are in use since 2018, in the Central and North Caucasus Regions canning industries (Fig. 1).

The Barin variety was bred using the method of complex multicomponent crossings with a multiple individual selection of varieties: ‘Fugue’, ‘Quartella’, ‘Usatyi 180-79,’ Rannii 301’ and “Rannii Gribovsky 11’. The Barin is a mid-season variety of vegetable peas (CATE 810 oC). The stem is 55–60 cm long, the height of the lower bean stem is 35–40 cm. The bean is 8–9.5 cm long and spiky as well. The average number of beans when harvesting during the period of technical ripeness is 6.5, on the productive node – 2–3 beans. It ripens easily. Commercial yield is 8.0–9.5 t/ha. Peas in technical ripeness green, lined, excellent taste. The seeds are green, 1000 pieces weight 160–170 g. The State Commission of the Russian Federation for the Testing and Protection of Breeding Achievements FSBI introduced the Barin variety in the State Register of Selection Achievements. They are in use since 2019 in the Central and Middle Volga Regions for canning industry (Fig. 2).
The Hercules cultivar was bred by hybridization from step crossing with subsequent multiple individual selection with the participation of varieties: ‘Quartella’, ‘Usatiy 180-79’, ‘Firstborn’. This is a mid-early (CATE 750 °C), a ripening variety of peas in a vegetable canning system. The stem is 60–70 cm long, the lower bean stem is 35–40 cm. The bean is blunt, 7–10-seed, 7–8 cm long. The average number of beans per plant is 6.5, on the productive node – 2–3 beans. It ripens easily. Productivity 8.0–9.0 t/ha. Peas in technical ripeness green, lined and have excellent taste. The seeds are cerebral, green, 1000 pieces weigh 160–170 g (Fig. 3). In use since 2018–2019.
The Federal State Budget Scientific Institution, the Federal Scientific Center of Science and Technology has won number of diplomas and medals for high technological and consumer qualities, the widespread introduction of pea varieties of canning vegetables. During the XI and XH agricultural exhibitions “GOLDEN AUTUMN” was awarded Gold Medals and Diplomas of the Ministry of Agriculture of the Russian Federation, and the Government of Moscow, RAAS and JSC ”All-Russian Exhibition Center GAO” for achievements in breeding and seed production of legumes and for the creation of a conveyor for pea processing.

This is the part of the study containing the achieved results.

4. Conclusion

Introducing into the production of new varieties of peas an intensive type of canned food, with an optimal combination of productivity elements, biochemical and taste qualities, with delayed polymerization of sugars and a high content of amylose fraction in starch will expand the supply of high-quality domestic raw materials to processing plants.

The study is concluded.

References

[1] Vishnyakova M A 2008 The gene pool of legumes and adaptive breeding as factors in the biologization and ecologization of crop production *Agricult. Biol.* 3 3–23
[2] Shpaar D, Ellmer F, Postnikov A, Taranuho G et al 2000 (Minsk: FU Aiform) 264 p
[3] Pivovarov V F and Pronina E P 2013 The main directions and results of selection and seed production of vegetable legumes in VNIISSOK *Vegetables of Russ.* 1 4–11
[4] Korobova N A, Titarenko A V, Korobov A P et al 2013 The new variety of pea alliance *Bull. of Orel State Agrar. Univer.* 2 29–30
[5] Ayupov D S, Davletov F A, Asylbaev I G et al 2019 Selection of high-yielding, high-tech varieties of field pea (Pisum sativum L.) *Legume Res.* 42(5) 615–9
[6] *The state register of selection achievements allowed for use* vol 1 *Plant Varieties* 2019 (Moscow: Fed. State Budg. Institut. Rosinformagroteh) 516 p
[7] Amelin A V 2002 The role of plant architectonics in the formation of highly productive and technological crops by pea varieties *Agrar. Russ.* 1 77–82
[8] Cieslarova J, Hybl M, Griga M and Smykal P 2012 Molecular analysis of temporal genetic structuring in pea (Pisum sativum L.) cultivars bred in the Czech Republic and in former Czechoslovakia 152 since the mid-20th century *Czech J. Genet. Plant Breedg*. 48(2) 61–73
[9] Burstin J, Chabert-Martinello M, Magnin-Robert J-B et al 2015 Genetic diversity and trait genomic prediction in a pea diversity panel *BMC Genomics* 16(1) 105
[10] Soldatenko A V, Pronina E P, Ushakov V A and Kotlyar I P 2018 *Guidelines for testing vegetable and gourds. Peas, beans and vegetable beans* (Moscow: Fed. Sci. Center for Vegetable Product.) pp 44–71
[11] Pivovarova V.F., Gypsy woman N.S. (ed) 2001 *Guidelines and recommendations for selection and seed production of vegetable legumes and cabbage* (Moscow: Higher. School) 168 p
[12] Federal State Budgetary Institution Gossortkomissiya Retrieved from: https://www.gossortrf.ru (Date of access: 12 November 2019)