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Review

History and Achievements of Buckwheat Breeding in the Republic of Tatarstan

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ABSTRACT

Common buckwheat (*Fagopyrum esculentum*) is an agricultural crop in the Russian Federation, which has been cultivated since the 15th century. Scientific breeding of buckwheat in the Republic of Tatarstan has a history of more than a century. During this time, 20 varieties of Tatar breeding have been included in the State Register of Breeding Achievements of the Russian Federation in different years. The article presents the history of breeding school and retrospective analysis of methods and achievements in buckwheat breeding at the Tatar Research Institute of Agriculture (before 1969 Kazan Republican Breeding and Experimental Station) on the basis of scientific reports of the laboratory of cereal crops and archival data.

Research work with common buckwheat (*Fagopyrum esculentum*) on the territory of the Republic of Tatarstan was first started at the Bugulma Experimental Station in 1912. Along with varietal studies, the development of the most important agro-techniques was carried out here, which helped to increase the yield of this crop in the Republic.

The first studies were carried out at the Shushar experimental field of the Arsk canton; it was there that work on the study of buckwheat variability was initiated, and the forms of *Fagopyrum esculentum* Moench, *F. emarqinatum* Roth, and *F. tataricum* Gaertner occurring in the Shushar area were described. The collected material was characterised by heterogeneity both in plant morphology, productivity and grain size. The maximum productivity of plants was 2.1 g with a 1000 fruit weight of 14 g. Average inflorescence productivity was negligible (0.1 g), plant productivity was ensured mainly due to abundant branching and prolonged flowering.

Figure 1. *I.I. Stutzer, 1930*

During this period, using group selection methods, work was started on the study and selective improvement of local forms from peasant crops. Soon, convinced of the low efficiency of group selection, breeders switched to repeated individual selection from local populations, which remained the main method of selection until the early 1930s. This work had no practical completion in this period: the isolated medium-ripening and early-ripening large-fruited material was lost without a trace.

After the reorganisation of the Kazan Agricultural Experimental Station and its incorporation into the Verkhnevolzhsky Breeding Centre, breeding work with buckwheat was resumed under the leadership of Alexandra Filippovna Shubina and Tatiana Vasilievna Tikhonova. During this period, the source material was considerably expanded due to the samples of the VIR collection. Along with local samples, forms from Transbaikal, Buryato-Mongol, Bashkir, Mordovian Republics, Central Black Earth Region, Ukraine and Belarus were studied. The main method of creating genetic variability was self-pollination and repeated individual selection. A.F. Shubina published works on revealing the hidden variability in the gene pool of buckwheat, and the use of inbreeding as a method of liberation from undesirable recessive traits (1936). Involvement in hybridisation of isolated new forms, such as dwarfism, terry florets, green-floweredness, albinism was not realised by the development of a new variety due to the low economic value of the isolated forms. High-yielding, drought-resistant samples of Buryato-Mongol buckwheat, large-fruited samples of Transbaikal buckwheat and early maturing local forms were promising for breeding improvement at that time.

Figure 2. *A.F. Shubina, 1932*

In order to create a variety with high yields, resistant to spring low temperatures and summer dry spells, attempts were made to develop the material on selective backgrounds of ultra-early sowing, and the study of reproductive biology of plants under drought conditions was initiated. However, even this work, due to limited volumes and methodological errors, did not result in the creation of a new variety.

It became effective since the discovery of highly productive old-growth seed material in the collective farm "Avangard" of the Yudinsky district of Tatarstan and involvement of the method of intervarietal hybridisation with individual selection from hybrid offspring in breeding work. In 1936, A.F. Shubina isolated several productive forms, one of which became the basis for breeding the variety "Kazanskaya Local". In 1938, this variety was zoned for a number of regions of the Non-Black Earth Region and TASSR, cultivated in crops until 1975. Due to its early maturity and drought resistance, it differed from the Bogatyr variety widely spread in those years with a higher stable yield and early ripening. In a competitive trial, the Kazanskaya local variety surpassed the standard and other varieties under breeding study by 15% with earlier ripening and fruit quality at the level of the standard variety Bogatyr.

From 1941 to 1945 at the Kazan Experimental Station a famous breeder and systematist Alexey Stepanovich Krotov worked with cereal crops. He began to study the effect of inter-sort free cross-pollination on buck-

wheat yield, obtained inter-sort hybrid populations from cross-pollination of local samples with varieties Kazanskaya, Bogatyr. The efficiency of the use of this method in breeding for increasing productivity, changing the vegetation period of hybrid offspring was shown. During this period, the main efforts of breeders were directed to the study of methodological issues of breeding and seed production, the causes of low drought resistance of buckwheat were analysed, the search for ways to protect crops from the effects of dry winds was conducted.

Since 1947, breeding work with buckwheat has been headed by Maria Nikolaevna Shumkova. Having analysed the reasons for the deterioration of the local population Kazanskaya in the process of seed production by progeny selection, and having summarised the results of intervarietal hybridisation, M.N. Shumkova started to create complex hybrid populations from free overpollination and to make selections from them. The method allowed to obtain two varieties of buckwheat - Kazanskaya 1 and Kazanskaya 26, but they did not spread due to the lack of advantage in yield, despite the rapid maturity and better technological qualities of fruits.

Figure 3. *M.N. Shumkova*

Analysis of the results of this period showed that the applied method of intervarietal crosses and formation of complex hybrid populations in the absence of reliable spatial isolation did not provide deep qualitative changes in the selected material. Even less effective was the method of re-pollination of mechanical variety mixtures, in which, regardless of the breeding value of the mixed components, there was only levelling of the traits on which selection was carried out.

Since 1968, a new stage in buckwheat breeding began at the Tatar Agricultural Experimental Station on the basis of the material formed by the outstanding breeder Natalia Nikolaevna Petelina at the All-Union Research Institute of Grain Legumes and Cereals. The original large-fruited diploid buckwheat gene pool created by her formed the basis for all subsequent buckwheat varieties of the Kazan period of her breeding activity, and was also used by other breeders during hybridisation as a source of economically valuable traits.

Figure 4. *N.N. Petelina*

Until the middle of the last century, the cultivated varieties were dominated by low-yielding, lodging, strongly branching and long flowering varieties from local populations.

To stabilise buckwheat yields at a higher level required a significant restructuring of the architectonics and biological nature of the buckwheat plant. Academician Engel Danilovich Nettevich, Professor Elena Semyonovna Alekseeva, Doctor of Agricultural Sciences Nikolai Valerianovich Fesenko and many other breeders of the Soviet Union who worked with buckwheat worked together with Natalia Nikolaevna to solve this complex problem.

To obtain genetic variability, along with vegetative-sex hybridisation, the method of polyploidisation was developed in breeding in those years. The first tetraploid buckwheat was obtained at the Institute of Biology of the USSR Academy of Sciences by Vladimir Vladimirovich Sakharov. From that moment in crosses conducted by N.N. Petelina, the tetraploid variety became an obligatory component - as a source of alien genetic material.

The first changes manifested themselves in the form of a slight enlargement of the seed, which were linked to a number of economically valuable plant traits. The material obtained formed the basis for the creation of a series of fundamentally new, high-quality large-fruited varieties. The first large-fruited varieties: Krasnostreletskaya and Mayskaya, released in 1971 - 1973, Kazanskaya large-grained - since 1983 widely cultivated in many buckwheat-growing regions of Russia, Ukraine, Belarus, Moldova and Kazakhstan.

Figure 5. *Planting a breeding nursery in 1972*

Natalia Nikolaevna laid the foundation for a fundamentally new method of creating source material and developed a new direction in buckwheat breeding. Her efforts and the work of her followers in the Tatar Research Institute of Plant Industry and Breeding, Siberian Research Institute of Plant Industry and Breeding, Samara Research Institute of Plant Industry and Breeding, Research Institute of Grain Farming of Kazakhstan created high-yielding large-fruited varieties of diploid buckwheat, the most important advantages of which are early maturity at high maturity, heat resistance and environmental plasticity, high quality of fruits and groats, manufacturability and cost-effectiveness of processing.

At present in Russian regions, about 300 thousand ha are sown with large-fruited buckwheat varieties of the Tatar Research Institute of Agriculture, the progenitor of which was the first large-fruited buckwheat variety Krasnostreletskaya, created by N.N. Petelina, which is about 20% of the area under buckwheat.

Since 1983 the work on buckwheat breeding in Tatar Research Institute of Agriculture was continued by N.N. Petelina's student Kadyrova Fanusya Zagitovna together with Galaktionova Vera Mikhailovna, Nizhegorodtseva Lubov Stepanovna, Kadyrova Luiza Ravilevna, Husnutdinova Alsu Tagirovna. During the years of joint work and subsequently created 16 varieties of buckwheat, which in different years have been zoned in buckwheat-sowing regions of the Russian Federation, the Republic of Moldova, Belarus and Ukraine. In co-operation with other breeding institutions of the Tatar NIISKh, buckwheat varieties Kuibyshevskaya 85, Irmenka, Shortanda large-grained buckwheat were developed.

Since this period and up to now, breeding work with buckwheat is aimed at increasing the adaptive potential of buckwheat varieties for regions with unstable agro-ecological conditionsThe method developed and tested in the Tatar NIISKh, which includes introgressive hybridisation with family-group selection of hybrid progeny on provocative backgrounds, is used in breeding for the increase of adaptive properties. This method of breeding allows to significantly expand the genetic variability of the source material for ecological stability of plants, as well as to improve the qualitative traits of yield. The result of work in this direction was a line of ecologically plastic and highly productive varieties, such as cold-resistant variety Kama and drought-resistant varieties Saulyk, Cheremshanka, Chatyr Tau.

In connection with the transfer of Kadyrova F.Z. to teaching, breeding work with buckwheat from 2017 continued at Kazan State Agrarian University and resumed again at the Tatar Research Institute of Agriculture, from 2022 under the guidance of her student Klimova Lilia Rafkatovna with the materials of her master's and PhD theses.

Figure 6 shows the yield dynamics of buckwheat varieties in the competitive variety trial of the Tatar Research Institute of Agriculture.

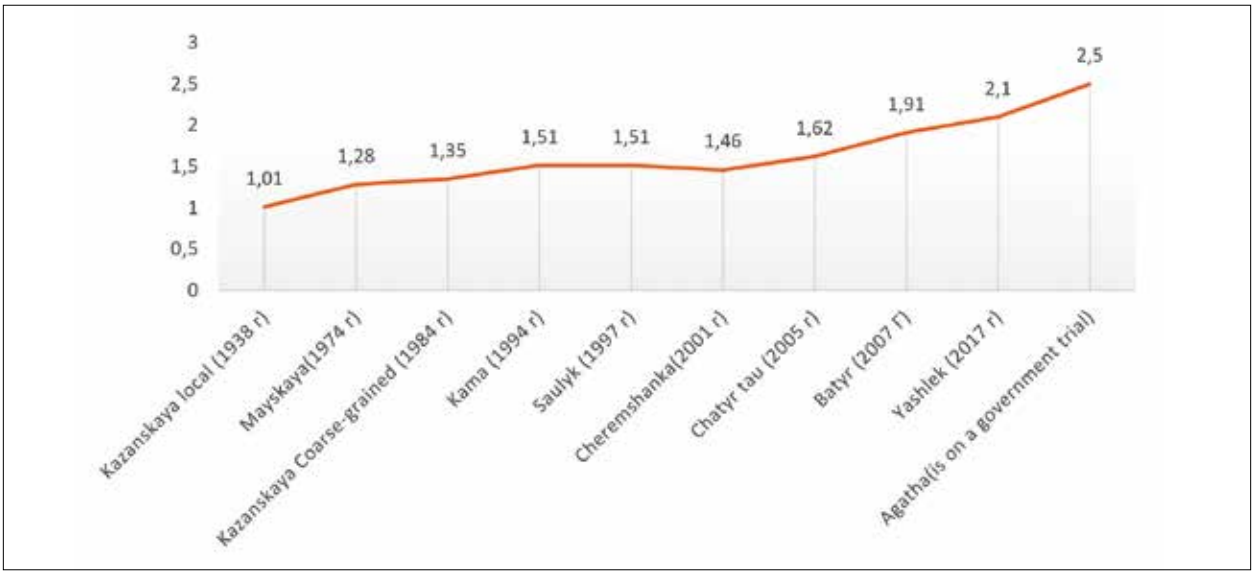

Figure 6. *Average yield of varieties obtained in the competitive variety trial, tonnes/ha*

Table 1 *- Morphostructural indices of* Fagopyrum esculentum *of TatNIISKh selection*

Variety name	Year of inclusion in the State Register	Plant height, cm.	Average number of nodes per plant, pcs.	Number of branches of the 1st order, pcs.	Number of inflorescences, pcs.	Grain weight per plant, g
Kazanskaya coarse-grained	1984	93.1	12.1	3.6	19.1	0.80
Kama	1994	85.4	10.7	3.6	17.9	0.92
Saulyk	1997	78.4	10.0	3.1	14.5	1.28
Cheremshanka	2001	76.3	11.2	3.6	19.2	0.92
Chatyr tau	2005	64.4	9.0	2.9	6.35	1.66
Batyr	2007	66.8	10.05	3.32	9.3	1.76
Yashlek	2017	63.9	9.29	2.43	6.5	2.29
Agatha	2024	60.9	9.11	2.48	5.5	2.52

Achievements of Kazan breeders of this century to create new varieties of buckwheat is the inclusion in the register of varieties allowed for cultivation in the regions of the Russian Federation, varieties Batyr (2008), Nikolskaya (2013), Yashlek (2017).

The data show that a noticeable increase in yield occurs with the involvement in breeding technology large diploid material and the first large-fruited varieties created by N.N. Petelina. Simultaneously with the increase in fruit size, over the years of breeding, the quality of the crop has increased due to the improvement of grain processing technology for groats, increase in the yield of pure kernel groats, its nutritional and dietary value.

In the last decade of the previous century and at the beginning of this century, the main trend in the creation of breeding material for the arid conditions of the Middle Volga region was the wide involvement of fascinated biotypes in the genetic basis of hybrid populations by selecting them from artificially created backgrounds unfavourable for buckwheat vegetation. This method contributed to an increase in the ecological plasticity of varieties, and an increase in the seed productivity of plants. It should be noted that these properties of varieties of Kazan varieties are manifested precisely in conditions with unfavourable period of crop formation, as evidenced by the data of varietal plots in the zones of their cultivation in the years of the State Variety Testing.

Significant changes have also occurred in the architectonics of the plant itself (Table 1). Polymorphism of populations created by selection of plants from extreme

Figure 7. *Varieties Mayskaya (1972); and Agatha (2024)*

backgrounds for vegetation allowed to form an optimal plant structure for these conditions.

Unproductive branching of plants was reduced, vegetative growth was reduced, the number of shoots and inflorescences decreased, but inflorescence size and seed production increased. Due to friendly and intensive flowering, better leaf supply of above-ground organs, the rate of attraction of plastic substances to fruits increased, and the dates of formation of the main part of the crop shifted to earlier dates. Short stems, stem thickening, its increased strength, reduction in the number and length of internodes in the branching zone of the stem, increase in the height of the first branch, which are characteristic of fasciated biotypes, allowed to shorten the time of crop formation and reduce grain losses at harvesting.

Buckwheat as a crop, corresponding to the conditions of biological farming, can become attractive for rural producers if it has the ability to form higher and more stable yields. Obviously, for this purpose it is important to increase the homeostasis of production processes in future varieties, which is able to keep the processes of plant vital activity at a stable level, which is possible by expanding the genetic diversity of the source material and the range of studied traits, moving from morphometric to a deeper assessment of physiological and biochemical properties of the material. Therefore, at present, the work of the buckwheat breeding laboratory is aimed at improving morpho-biological methods of evaluation, as well as the development and introduction of modern biotechnological and genetic studies in the process of creating new breeding material.

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IZVLEČEK

Zgodovina in dosežki žlahtnjenja ajde v Tatarstanski republiki

Navadno ajdo (*Fagopyrum esculentum*) na ozemlju Ruske federacije, pridelujejo že od 15. stoletja. Znanstveno podprto pridelovanje ajde ima v Tatarstanski republiki več kot stoletno zgodovino. V tem času je bilo v državni register žlahtniteljskih dosežkov Ruske federacije v različnih letih vključenih skupaj 20 sort ajde požlahtnjenih v Tatarstanski republiki. Članek prikazuje zgodovino žlahtnjenja in retrospektivno analizo metod ter dosežkov pri gojenju ajde na Tatarskem raziskovalnem inštitutu za kmetijstvo (pred letom 1969 se je imenoval Kazanska republiška žlahtniteljska in poskusna postaja) na podlagi znanstvenih poročil laboratorija za žita ter arhivskih podatkov.