

From experiments to practice

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60 YEAR BRED CONVEYOR OF APPLE VARIETIES, THEIR RESISTANCE TO SCAB AND BIOCHEMICAL CHARACTERISTICS OF FRUITS

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Abstract

The results of apple breeding at the All Russian Research Institute of Fruit Crop Breeding (VNIISPK) for 60 years (1953-2013) are given. The basic sections of breeding are shown (the development of scab immune triploid apple varieties with higher contents of nutrient and biologically active substances in fruit). The biochemical characteristics of fruits in 47 apple varieties released from VNIISPK and included into the State Register are given. The development of the varieties with different dates of maturing and length of storage life allows providing the apple calendar of home apple consumption during the whole year round by the way of purposeful selection of varieties. First in Russia and in the world a series of triploid apple varieties have been produced from crossing between plants with different ploidy. These varieties ensure more regular fruiting and high fruit marketability. The VNIISPK varieties are widely introduced in the production and amateur orchards in a number of regions of Russia and Belarus; they are passing testing in the Ukraine, Kazakhstan and other countries.

Keywords: apple, varieties, breeding, scab immunity, dates of fruit maturing, biochemical composition of fruit, triploidy.

Apple breeding is focused on the improvement of assortment and producing varieties with high yield, different dates of ripening, and suitable for intensive horticulture. Successful practical results are undoubtedly based on fundamental study of plant genetics, physiology, biochemistry, etc. [1]. Apple varieties immune or high tolerant to scab are required, in fact, in all Russia regions. In the view to this, genetic and immunological research of plant tolerance to scab have been conducted in All-Russian Research Institute of Breeding Fruit Crops (VNIISPK). We improved the technique of scab experimental infection, selected virulent and aggressive scab biotypes, developed crossing programs. Studies were governed by and carried out with V.V. Zhdanov [1]. Recently, the digenic varieties $V_f + V_r$ and $V_r + V_m$, and the varieties with oligo-polygenic complex scab resistance are mainly produced.

Based on knowledge about the formation of male and female gametes one can plan crossings required to obtain enough hybrids for further selection. Triploids were shown to be best produced in crosses like $2\times/4\times$ and $4\times/2\times$ ($\text{♀}/\text{♂}$). Due to these crosses a set of first Russian triploid apple varieties has been produced. These varieties are generally characterized by more regular yielding year after year, the high fruit marketability, an increased self-fertility, thus being quite promising in practical use. For the polyploidy-based breeding program, the cytoembryological study is essential allowing us to control the peculiarities of generative system in the parent plants, and estimate ploidy in the hybrids when the parent forms with different ploidy were crossed.

For many years the hardiness, a resistance to diseases, improved chemical compositions, small height, the compact and columnar habit, polyploidy and

self-fertility remained a priority in our breeding. In breeding research we used common techniques [2-5].

Genotypic characteristics and main parameters of tolerance, production and fruit quality in the apple varieties originated from All-Russian Research Institute of Breeding Fruit Crops for 60 year period (those included into State Register of the Russian Federation are shown herein)

Variety	Ploidy and scab resistance	Fruit weight, g	Sugars, %	Total acidity %	Sugar to acidity index	Ascorbic acid, mg/100 g	P-active substances, mg/100 g
Summer varieties							
Avgusta	3×	160	10.5	0.73	14.4	9.8	422
Daryena	3×	170	10.3	0.76	13.6	8.8	422
Zhelannoe		140	10.6	0.61	17.4	4.4	384
Maskovskoe	3×, V_f	200	10.7	0.71	15.1	17.5	318
Orlinka		140	10.4	0.73	14.2	7.4	314
Orlovim	V_m	130	10.2	0.77	13.2	8.8	299
Osipovskoe	3×	130	12.1	0.49	24.7	8.1	263
Radost' Nadezhdy		150	10.0	0.64	15.6	4.7	474
Ranee aloe		130	9.5	0.78	12.2	9.4	313
Yubilar	3×, V_f	130	9.4	0.86	10.9	11.5	387
Yavlochnii Spas	3×, V_f	210	10.4	0.70	14.9	9.4	402
Melba (control)		125	9.9	0.71	13.9	11.2	389
Papirovka (control)		130	9.0	0.75	12.0	15.1	259
Autumn varieties							
Zaryanka	V_m	130	10.1	0.79	12.8	18.0	419
Orlovskii pioner	V_m	140	10.0	0.87	11.5	14.8	514
Orlovskoe polosatoe		150	10.3	0.81	12.7	8.5	261
Pamyat' Isaeva	V_m	150	10.4	0.56	18.6	6.6	325
Slavyanin	V_m	150	10.5	0.93	11.3	11.4	360
Solnyshko	V_f	140	9.8	0.84	11.7	7.7	424
Osennee polosatoe (control)		140	9.8	0.59	16.6	9.0	248
Winter varieties							
Aleksandr Boiko	3×, V_f	200	10.7	0.51	21.0	4.4	351
Afrodira	V_f	130	10.4	0.48	21.7	6.8	464
Bezhin lug	3×	150	9.3	0.55	16.9	7.4	436
Bolotovskoe	V_f	150	10.4	0.40	26.0	11.1	477
Ben'yaminovskoe	V_f	130	9.7	0.62	15.6	4.8	235
Veteran		130	10.3	0.71	14.5	19.4	229
Zdorov'e	V_f	140	9.6	0.88	10.9	7.8	449
Ivanovskoe	V_f	150	11.8	0.85	13.9	19.5	432
Imrus	V_f	140	9.6	0.77	12.5	9.3	433
Kandil' orlovskii	V_f	120	10.2	0.56	18.2	7.2	558
Kulikovskoe		125	10.2	0.53	19.2	15.3	317
Kurnakovskoe	V_f	130	10.8	0.73	14.8	11.3	380
Morozovskoe		160	8.7	1.04	8.4	8.0	299
Nizkorosloe	3×	130	10.6	0.35	30.3	18.0	293
Olimpiiskoe		130	10.9	0.77	14.2	15.4	280
Orlik		120	10.8	0.43	25.1	8.5	222
Orlovskaya zarya		135	10.3	0.63	16.3	15.0	334
Orlovskii partizan	3×	190	11.8	0.41	28.8	7.7	426
Orlovskoe poles'e	V_f	140	10.0	0.85	11.8	6.9	438
Pamyati Khitrovo	V_f	170	10.6	0.89	11.9	3.5	480
Pamyat' voinu		140	10.6	0.51	20.8	7.1	182
Pamyat' Simakinu	3×	160	9.5	0.90	10.6	8.7	474
Patriot	3×, V_m	240	11.9	0.46	25.9	9.0	449
Pepin orlovskii		140	10.2	0.59	17.3	15.3	241
Pozhdestvenskoe	3×, V_f	140	9.9	0.57	17.4	4.1	368
Svezhest'	V_f	140	10.1	0.80	12.7	12.5	377
Sinap orlovskii		150	9.9	0.56	17.7	13.4	205
Start	V_f	140	10.9	0.57	19.1	11.0	404
Stroevskoe	V_f	120	10.4	0.61	17.0	7.0	396
Yubilei Moskv	V_f	120	9.6	0.67	14.3	5.6	352
Antonovka obyknovennaya (control)		140	8.7	0.99	8.8	14.5	340
Severnyi sinap (control)		120	9.0	0.58	15.5	13.9	137

Note. 3× marks triploids, V_f , V_m indicate the presence of immunity gene.

Regular studies on apple breeding have been started in 1953 by E.N. Se-

dov. Until 1955 all crosses have been carried out in I.V. Michurin Research Institute of Horticulture (Michurinsk, Tambove Province), then at the Orel Experimental Station, the ancestor of VNIISPK. In this, main contemporary approaches are being used [1]. For 60 year period (1953–2013) a total of 4.8 million flowers have been pollinated with 853 thousand seedlings grown and 187 thousand ones replanted into breeding gardens of which 10.6 thousand ones are being grown. Moreover, 171 elite seedlings have been selected. A total of 74 varieties were submitted to state testing, and 47 varieties of different ripening were included into the State Register (Table). The apple varieties produced in VNIISPK are widely used in commercial plantations, by farmers and in private gardens in Russia and Belorussia, and also are tested in Ukraine, Kazakhstan, etc.

Of 47 varieties originated from VNIISPK, there are 11 ones of summer ripening, 6 ones of autumn ripening, and 30 ones of winter ripening (see Table). Under the climate of Orel Province, the ripening in the summer varieties occurs both in first half of August (e.g., Rannee aloe, Maslovskoe and Yablochnii Spas varieties) and in second half of August (e.g., Orlovim, Zhelannoe, Radost' Nadezhdy, etc.). Of autumn varieties, the Orlovskii pioneer is the early ripening one with the yield harvesting in second half of August and fruits stored until October the end. Later ripening is characteristic of other varieties of this group. In Orlovskoe polosatoe variety the ripening occurs in September the beginning, and its fruits are easy stored till December the end, and in Solnyshko variety it is September 15–20 and December, respectively. In Afrodita, Orlovskoe poles'e, Rozhdestvenskoe, Bolotvskoe varieties fruits are harvested in the middle of September and stored in a refrigerator till January the end. The longest storage is peculiar to Veteran variety (till March the middle), Kulikovskoe (till March the end), Sinap orlovskii (till May) and Svezhest' (till May and beyond) [1]. Thus, a broad diversity of apple varieties with different ripening and storage time can be offered as an «apple conveyer» to provide people with fresh fruits nearly year-round.

Selection for scab immunity is being conducted in VNIISPK since 1976 (E.N. Sedov et al., 1983; V.V. Zhdanov et al., 1991). A total of 2.4 million flowers have been pollinated with 464.6 thousand seedlings grown. A total of 20 scab-immune apple varieties were produced, including Maslovskoe and Yablochnii Spas varieties of summer ripening [6]. These varieties are characterized by a short time of fruit maturation and the high marketability, at that, the high level of ascorbic acid (17.5 mg/100 g) is peculiar to Maslovskoe variety. The ripening of another scab-immune variety, Solnyshko, occurs in late autumn. Solnyshko plants are characterized by high yield and attractable appearance. The best scab-immune apple winter varieties are Bolotvskoe, Ven'yaminovskoe, Imrus, Kandil' orlovskii, Rozhdestvenskoe, and Svezhest'. In these varieties, short fruit ripening, high yield and marketability are peculiar. Kandil' orlovskii variety is also peculiar in specific cone-like shape of fruits with high level of P-active substances, and in Rozhdestvenskoe variety the fruits are especially delicious.

Biochemical study indicated a high sugar level in fruits (above 10.6 %) in Maslovskoe, Aleksandr Boiko, Kurnakovskoe, Orlik, Olimpiiskoe, Start, Orlovskii partisan, Ivanovskoe, Patriot and Osipovskoe varieties [7–9]. Ascorbic acid content in Maslovskoe (17.5 mg/100 g), Zaryanka (18.0 mg/100 g), Nizkorosloe (18.0 mg/100 g), Veteran (19.4 mg/100 g) and Ivanovskoe (19.5 mg/100 g) varieties is superior to that in other varieties, and high accumulation of P-active substances (over 450 mg/100 g) is characteristic of Orlovskoe poles'e, Pamyati Khitrovo, Pamyat' Semakinu, Radost' Nadezhdy varieties. High marketability and fruit weight is characteristic of the triploid varieties Patriot (240 g), Yablochnii Spas (210 g), Aleksandr Boiko (200 g), Maslovskoe (200 g), Orlovskii partisan

(190 g), Daryena (170 g) [10]. The triploid scab-immune apple varieties are recommended for commercial use, particularly, summer varieties Maslovskoe, Yablochnii Spas and winter varieties Aleksandr Boiko and Rozhdestvenskoe.

Thus, due to 60 year research, a total of 74 apple varieties are produced of which 47 are included into State Register of breeding achievement allowed for practical use in the Russian Federation. These varieties differ in ripening characteristics thus allowing us to construct a fresh apple «conveyor» for year-round consumption. Long-term study of the biochemical composition of fruits makes it possible to choose for this «conveyor» the varieties with a high content of nutrients and bioactive substances. Among the varieties, a total of 20 scab-immune ones and 12 triploid ones with the high marketability have been produced. These varieties are widely used in commercial and private gardens in different Russian regions and in Belorussia, being also tested in Ukraine, Kazakhstan, etc.

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