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Genetics and Selection

The Results of the Crossing of Winter Triticale with Soft Wheat Cultivars and First Generation Hybrids Productivity

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Dedicated to the blessed memory of our friend, talented young scientist Marina Jashi, who succeeded in Triticale breeding

ABSTRACT. The present investigation has shown that setting of hybrid seeds totalled 32.1% in the case of using hexaploid Triticale as a female parent and 66.8% in backcrosses, but when using wheat as a female parent underdeveloped, heavily shriveled, practically nonviable grains were obtained. When crossing Triticale with wheat the process of grain development proceeds with insignificant deteriorations: hybrid grains are comparatively well filled and their germination capacity in the field reaches 84%. By productivity plants of the first generation lag behind parental forms: number of grains in the wheat ear varies from 27.5 to 44.0 and from 52.5 to 54.5 in Triticale, while in hybrids this index fluctuates between 12.6 and 24.5. *© 2009 Bull. Georg. Natl. Acad. Sci.*

Key words: *Triticale, shriveled grains.*

Introduction. Analysis of scientific literature shows that the genera united in the Poaceae family, namely wheat and rye, cross with each other with difficulty. At the same time it is also known that if crossing is achieved, biotypes carrying positive traits of both genera very rarely can be singled out from the hybrid populations. That is why geneticists and breeders worldwide and in Georgia as well consider a new culture - Triticale, obtained as a result of crossing the above mentioned two genera, as a very prospective crop for using in crosses. In this case Triticale should serve as a mediator.

Data on crossing Triticale with wheat are abundant in scientific literature. Crosses of such kind started in the 1960s, but breeders have so far failed to obtain practically valuable wheat varieties on the basis of this new culture. The first attempts in this direction were made by A. F. Shulindin in Ukraine and by P. Naskidashvili, Ts. Samadashvili and M. Jashi in Georgia.

Because of the absence of data confirming the crossability of Triticale with soft wheat and productivity of obtained hybrids, in the present investigation we give the results of a study of hybrids obtained via reciprocal crossing of Triticale with winter soft wheat.

Initial material and methods. Two varieties of hexaploid Triticale – Kartli 2 and Kartli 5 (obtained with participation of winter hard wheat (Hordeiforme 931 and × 911) and rye variety Kharkovskaya 55 have been chosen for crossing. The following varieties of winter soft wheat participated in the crossings: Mironovskaya 808, Bezostaya 1, Tbilisuri 5, Tbilisuri 8, Mukhranula 7, Vardzia, Dolis Puri 35-4, Korboulis Dolis Puri, Akhaltsikhis Tsiteli Dolis Puri.

Table 1

Crossing hexaploid Triticale with winter cultivars of soft wheat

Male wheat cultivars and forms	Male Triticale variety							
	Kartli 2				Kartli 5			
	Number of pollinated flowers 1998-1999	Setting of hybrid grains, %			Number of pollinated flowers 1998-1999	Setting of hybrid grains, %		
		1998	1999	Average		1998	1999	Average
Bezostaya 1	1400	30.6	33.5	32.5	1500	42.5	45.1	43.8
Mironovskaya 808	1100	29.5	31.6	30.1	10000	34.5	47.5	41.0
Tbilisuri 5	1500	39.2	42.3	40.8	16000	44.5	52.3	48.6
Tbilisuri 8	1400	33.5	35.1	34.3	1500	38.3	40.2	39.2
Mukhranula 7	1400	31.5	32.7	32.1	1400	35.1	37.6	36.3
Vardzia	1100	15.6	17.9	16.2	1200	21.4	29.5	25.4
Dolis Puri 35-4	1200	25.9	27.2	26.5	1300	29.5	31.3	30.3
Korboulis Doils Puri	1300	21.4	25.7	24.3	1400	27.3	29.6	28.4
Akhaltsikhis Tsiteli Dolis Puri	1400	11.5	22.1	16.8	1500	19.4	24.2	21.8
Average	-	26.5	29.9	28.2	-	34.1	37.9	36.0

Parental forms taking part in crosses have an equal number of chromosomes (2n=42), but differ in genome composition: genomic structure of Triticale varieties is A_1, A_1, B_1, B_1, BR and that of wheat varieties - AABBDD.

In order to establish the effect of crossing direction on hybrid grain setting and their viability, reciprocal crossing has been carried out: direct cross – Triticale× wheat and reverse cross -wheat×Triticale. The castrated flowers were pollinated with limited-free method [1].

Crossability was determined by two indices: setting of hybrid grains and germination capacity of hybrid grains.

Hybrid grains were sown in autumn, on the well fertilized fallow, nutrition medium was of 5×20 cm dimensions. Parental forms were sown next to hybrids: during the whole vegetation period phenological observations were carried out. From each hybrid combination 25 plants were taken with roots in order to determine the morphological characteristics and elements of productivity and numerical data obtained from 25 main ears were processed statistically.

Results and discussion. The obtained results show that hexaploid triticale quite easily crosses with soft wheat. But Triticale varieties differ from each other by the ability of crossing with soft wheat (Table 1).

Hereditary-genetic features of wheat varieties to a great extent determine fertilization of ovule in varieties of Triticale. The following varieties are characterized by good pollination capacity: Bezostaya 1, Mironovskaya 808, Tbilisuri 5, Tbilisuri 8, Mukhranula 8, Mukhranula 7. Comparatively low number of seeds were set when the following varieties of soft wheat were used as pollinators: Vardzia, Dolis Puri 35-4, Korboulis Dolis Puri and Akhaltsikhis Tsiteli Dolis Puri. Most hybrid combinations differed from each other in crossability according to years. This may be explained by the influence of meteorological factors on fertilization and development of hybrid grains.

Results have shown that at backcrossing (wheat× Triticale) number of hybrid grains is twice as much as compared with direct crossing when soft wheat was pollinated with pollen of Triticale (Table 2).

Setting of hybrid grains was nearly equal according to years and combinations. The process of development of normal and viable hybrid grains was dependent on female plant: hybrid grains were more filled and viable in those cases when Triticale was used as a female parent and soft wheat varieties - as pollinators. Grains obtained as a result of backcrossing (wheat×Triticale) were shriveled and practically ungerminable. Similar results were obtained by other researchers as well [1-7].

Shulindin and Surkova [7] have shown that the main difference between the reciprocal crosses appears from the initial stage of grain embryogenesis, namely at the development of hybrid endosperm. Degeneration of hybrid grain in wheat×Triticale combination starts after transition from nuclear state into cellular phase, as a result of which it dies at an early stage. Great number of hybrid grains is obtained, most of them are without endosperm and an absolute majority is lacking the embryo. Such grains are nonviable.

Table 2

Male wheat cultivars and forms	Male Triticale cultivar							
	Kartli 2				Kartli 5			
	Number of pollinated flowers 1998-1999	Setting of hybrid grains, %			Number of pollinated flowers 1998-1999	Setting of hybrid grains, %		
		1998	1999	Average		1998	1999	Average
Bezostaya 1	10000	72.5	80.1	76.1	800	64.6	82.1	73.3
Mironovskaya 808	110-0	70.4	72.5	73.9	900	72.5	75.5	74.0
Tbilisuri 5	1200	79.5	84.5	82.0	1000	82.1	88.5	85.3
Tbilisuri 8	900	68.6	76.6	72.6	800	69.8	71.5	70.6
Mukhranula 7	700	71.5	76.5	74.0	700	72.1	77.6	74.6
Vardzia	800	46.5	52.5	49.1	800	47.6	55.5	51.6
Dolis Puri 35-4	500	58.1	64.5	61.3	600	59.1	62.1	60.8
Korboulis Doils Puri	600	53.5	56.5	55.0	700	54.5	58.5	56.5
Akhaltsikhis Tsiteli Dolis Puri	900	60.2	62.4	61.3	1000	61.2	65.5	63.6
Average	-	64.4	69.9	67.1	-	63.7	69.6	66.6

At direct crossing (Triticale×wheat) fewer anomalies take place in the process of embryonic development of hybrid grains on female plant – Triticale. Partial degeneration of endosperm causes some deformations of hybrid grain, which do not essentially affect its viability. The number of obtained hybrid grains was found to be dependent on the direction of crossing, i. e, on the choice of a female parent.

The results obtained have shown that Triticale genotype has a decisive role in obtaining viable hybrid grains when Triticale is taken as a female form in crossing. Hybrid plants obtained as a result of crossing

Table 3

Field germination of hybrid grains obtained as a result of crossing winter Triticale and soft wheat cultivars

Male wheat cultivars and forms	Number of combinations	Number of sown grains		Number of germinated plants		Germination, %				
		1998	1999	1998	1999	1998	1999	Average	Minimum	Maximum
Bezostaya 1...	1	200	200	192	198	96	99	97.5	–	–
Kartli 2	1	500	200	450	182	90	91	90.5	–	
Kartli 5	1	500	200	464	185	92.87	94.5	93.6	–	–
F1 Kartli 2 × wheat	9	1475	1295	1110	980	5.7	75.7	75.4	69.3	81.7
F1 wheat × Kartli 2	9	1036	1283	11	3	0.2	0.2	0.6	0	1.5
F1 Kartli 5 × wheat	9	2354	1862	1766	1502	80.7	80.7	77.5	70.7	82.2
F1 wheat × Kartli 5	9	1238	1367	8	5	0.4	0.4	0.5	0	1.7
F1 Triticale × wheat	18	3828	3157	2876	2482	78.6	78.6	76.7	69.2	82.2
F1 wheat × Triticale	18	2274	2650	19	8	0.3	0.3	0.6	0	1.7

Triticale´wheat due to the filling of grains in the stage of germination-tillering develop slowly as compared with parent plants, though after coming into winter period successfully pass winter, grow well in spring and summer to give a generation.

In crosses Wheat×Triticale protein complexes of immune biological incompatibility of parental forms manifest themselves in wheat cytoplasm. In the first instance incompatibility of Triticale nucleus with wheat cytoplasm causes manifestation of syngamy at a high rate and breaking of processes of embryonic development of hybrid grains. Such crosses practically did not yield any hybrid grains. But in single cases, at a wide scale crossing we managed to get single plants (Table 3). For example, of 2274 grains sown in the first year only 19 germinated, out of which 10 died in the phase of a first leaf as a result of deficiency of nutrients in the grain, 6 plants were lost during the winter period as a result of weak development and only 4 plants gave a generation. The same regularity was preserved in the next year, of 2650 grains only 8 plants developed, of which only 2 plants entered the period of winter.

Table 4

Productivity of hybrids of the first generation obtained as a result of crossing hexaploid Triticale with winter soft wheat cultivars

Cultivars	Plant height	Tillering		Main ear				Per single plant		
		Total	productive	Length, cm	Number of spikelets	Mass of grain, g	Number of grains	Number of grains	Mass of grain	Mass of 1000 grains
Bezostaya 1	95.5	7.5	6.5	9.5	21.5	41.5	2.2	263.3	14.3	44.0
Kartli 2	139.5	8.1	7.8	12.5	27.5	54.5	2.9	394.0	18.1	51.7
Kartli 5	138.4	7.3	6.5	12.6	28.2	52.5	3.2	331.3	20.9	50.8
Mironovskaya 808	120.5	9.0	6.3	12.7	21.0	47.2	2.3	272.1	14.3	43.5
Kartli 2 × Mironovskaya 808	132.5	7.7	6.7	19.5	26.5	12.6	0.4	77.0	2.5	26.9
Kartli 5 × Mironovskaya 808	134.6	7.6	5.5	6	24.5	16.5	0.5	101.7	2.7	32.1
Kartli 2 × Bezostaya 1	127.5	8.2	6.2	12.5	22.5	19.5	0.6	107.3	3.7	27.0
Kartli 5 × Bezostaya 1	129.3	8.6	6.0	11.5	24.2	21.1	0.5	130.8	3.0	28.7
Kartli 2 × Tbilisuri 5	125.6	9.2	8.1	11.6	24.5	19.0	0.4	114.0	3.3	29.1
Kartli 5 × Tbilisuri 5	129.3	9.4	7.5	11.7	25.1	22.0	0.5	138.2	3.8	28.2
Kartli 2 × Dolis Puri 35-4	122.3	10.5	8.5	12.0	23.2	22.2	0.6	166.0	5.1	29.1
Kartli 5 × Dolis Puri 35-4	125.6	10.0	8.2	11.6	24.2	24.5	0.7	208.2	5.7	32.0
Kartli 2 × Akhaltsikhis Tsiteli Dolis Puri	122.4	10.4	8.5	12.7	23.5	22.5	0.4	131.3	3.4	31.5
Kartli 5 × Akhaltsikhis Tsiteli Dolis Puri	124.6	10.6	7.8	11.4	23.2	21.3	0.5	156.2	3.9	29.5
Tbilisuri 5	97.5	9.2	8.7	11.5	12.5	40.5	2.0	324.0	16.0	40.6
Dolis Puri 35-4	115.1	10.6	7.9	9.5	18.2	22.5	1.6	231.0	12.3	32.5
Akhaltsikhis Tsiteli Dolis Puri	113.6	10.7	7.5	9.3	18.0	28.5	0.2	215.5	11.6	37.6

Plants germinated in the group of crosses wheat × Triticale in the period of autotrophic nutrition, at the initial stage, grew slowly due to the lack of nutrients in endosperm and died before passing to heterotrophic nutrition.

When using wheat as a female parent hybrid plants were obtained when aboriginal varieties of soft wheat Akhaltsikhis Tsiteli Dolis Puri, Korboulis Dolis Puri and the variety obtained by breeders Dolis Puri 35-4 and Tbilisuri 5 were used as a female parent. Plants of the first generation by height were close to the female parental wheat form than to the male parent – Triticale: they held middle position between wheat and Triticale. Ear was of rose color, compact, quadratic, dense at the top, by height more inclined towards Triticale than wheat. Tooth of spikelet keel is of the type characteristic of soft wheat, obtuse, short, keel is well expressed to the base of spikelet. Red color of ears is dominating.

The obtained hybrids are characterized by low productivity: nearly 8-17 grains have developed per ear, and 34-38 on the whole plant. By shape and fulness grains ranged from filled to shriveled.

When Triticale was used as a female plant, the hybrid plants of the first generation were uniform by morphological signs within the same combination. As a rule heterosis by plant height was not a case, but plants evidently tend toward Triticale by height (Table 4). Hybrids and their parental forms gave numerous tillers. Tillering rate in hybrids was higher as compared with parental forms. Leaves of hybrid forms were bigger in size, being covered with wax type film characteristic of Triticale. On all stems and leaves of all hybrids coloration characteristic of rye is strongly expressed before entering the maturation phase.

Compactness of the ear and structure of morphological signs, excluding the awned forms, held an intermediate position between the parental forms. By length it was close to Triticale and even longer. Spikelet keels were nearly of the same type as those of wheat. By crossing Triticale with awnless wheat awnlessness dominates in the first generation. Awn-like appendix starts from the middle part of the ear and reaches the top, being 2-4 cm long.

Hybrids exceeded the initial forms by the number of spikelets in ear. By productivity they lag behind the parental forms. This may be explained by the fact that there is no similarity between the DD genome of wheat and RR genome of rye, causing deterioration of chromosome conjugation in diakinesis and anomalies in the variety, producing abortive gametes.

The number of grains in hybrid ears is much less than in parental forms. The number of grains in ears of parental plants ranges from 27.5 to 54.5, while it varies from 12.6 to 24.5 in hybrids. Difference was marked in the mass of 1000 grains as well (Table 4).

Essential difference was obtained between combinations in relation to the genotype of parental components. Increased grain number was noted in combinations where the following wheat varieties Tbilisuri 5 and Dolis Puri 35-4 participated in crossings with both Triticale varieties.

Within each hybrid combination grains are uneven by shape, size, fullness and can be divided into 3 groups: **Triticale type** – prolonged, big, well filled, slightly deformed; **wheat grain type** - shortened, filled, but small; and the third one – type of hybrid grain obtained in the first year – prolonged, heavily deformed, shriveled.

Hybrid grains are of red color, horn-shaped. Great number of grains by type falls to hybrid grains of the first generation, and small number of grains resembles soft wheat and Triticale. Grains of the first and the second types are more or less deformed, but contain normal endosperm and embryo. Grains of the third type are almost without endosperm and have low germinability. Germinability of hybrid grains of the second generation is not high, ranging from 35 to 65% according to combinations.

All hybrids are immune, like Triticale.

Conclusions: when crossing winter hexaploid Triticale with varieties of soft winter wheat the setting of hybrid grains is twice as high in crosses where soft wheat is taken as a female parent and Triticale is a pollinator. In such crosses biological incompatibility of Triticale nucleus with wheat cytoplasm takes place, causing physiological-biochemical and structural alterations in the process of embryonic development of hybrid grains. As a result underdeveloped, shriveled grains are obtained with 2.9-7 g absolute mass. Such grains are practically ungerminable. Only in certain cases at wide scale crosses single viable hybrid plants can be obtained.

When using Triticale as a female parent and soft wheat varieties as pollinators, the process of development of hybrid grains proceeds with slight alterations and well-filled, comparatively viable grains are obtained. Reciprocal hybrids are similar by morphological traits and hold an intermediate position between the parental forms. Morphological traits of Triticale are strongly inherited in hybrids of the first generation.

გენეტიკა-სელექცია

საშემოდგომო ჰექსაპლოიდური ტრიტიკალეს რბილი ხორბლის ჯიშებთან შეჯვარებადობის და პირველი თაობის ჰიბრიდების პროდუქტიულობის შესწავლის შედეგები

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ეძღვნება ჩვენი მეგობრის, ნიჭიერი ახალგაზრდა მეცნიერის, ტრიტიკალეს წარმატებული სელექციონერის მარინა ჯაშის ნათელ ხსოვნას

ჰექსაპლოიდური ტრიტიკალეს მდედრობით ფორმად, ხოლო დამამტვერიანებლად რბილი ხორბლის გამოყენებისას ჰიბრიდული მარცვლების გამონასკვამ საშუალოდ შეადგინა 32,1%, ხოლო შებრუნებულ კომბინაციებში — 66,8%. მაგრამ შეჯვარებაში მდედრობით ფორმად რბილი ხორბლის გამოყენებისას მიიღება განუვითარებელი, ძლიერ ბჟირი მარცვლები, რომლებიც პრაქტიკულად არასიცოცხლისუნარიანები არიან. ტრიტიკალე ხორბლის ჰიბრიდებში მარცვლის განვითარების პროცესი მიმდინარეობს უმნიშვნელო დარღვევებით: ჰიბრიდული მარცვლები შედარებით უკეთესადაა ამოვსებული, რომელთა მინდვრად აღმოცენება აღწევს 84%-მდე. პირველი თაობის მცენარეები ნაყოფიერებით მნიშვნელოვნად ჩამორჩებიან მშობლიურ ფორმებს: ხორბლის თავთავში მარცვლების რიცხვი ცვალებადობს 27,5-დან 44,5-მდე, ხოლო ტრიტიკალეში — 52,5-დან 54,5-მდე, ჰიბრიდებში კი ეს მაჩვენებელი მერყეობს 12,6-დან 24,5-მდე ფარგლებში.

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