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Triticale Breeding In Georgia and the Prospects for Its Use

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The creation of triticale is a great achievement of geneticists and breeders around the world. This new cereal crop combines the positive characteristics and traits of wheat and rye. Triticale is getting attention due to the increased protein concentration with the essential amino acids containing in it, is characterized by high adaptibility (frost resistance, strong immunity to fungal diseases, less demands on soils and environmental conditions) and high potential of a spike productivity. Triticale is considered the bread of the future and the future belongs to it.

The biomass of triticale is a valuable feed for livestock, because it contains a large amount of sugars and carotinoids, proteins and the essential amino acid - lysine containing in the protein. Its stress tolerance and adaptibility, makes it more suitable for producing in the areas, where wheat and rye cannot be produced. Thanks to these valuable traits, high yielding triticale varieties occupy more and more areas in every wheat producing country. Due to its numerous advantages over wheat, about 100 million hectares of triticale were grown worldwide.

Further progress in triticale breeding is possible after conducting a comprehensive study of existing forms, their selection, creating a completely new selection initial material using various methods of crossing, as a result of which will be eliminated such negative traits as: low fertility of spike, its fragility and poor threshing ability, shriveled grain, pre harvest sprouting and poor bread- making quality. For the elimination of these problems, at the Department of Genetics and Selection of the Agricultural University of Georgia, Prof. Tsotne Samadashvili has began working on the improvement of triticale by breeding.

Methods of improvement of triticale by breeding in Georgia

From 1978 to 1990, interspecies and intergeneric crossing of triticale populations of various genetic origins was carried out. In total, more than 750 hybrid combinations were produced and analyzed. A detailed analysis of the obtained results revealed that the improvement of the hybrids of hexaploid triticale by breeding can be carried out in the following main directions:

1. Crossing octoploid triticale X hexaploid triticale according to the following scheme: octoploid X hexaploid;
2. Hybrid intercrossing: hybrid (Fn), hexaploid X hybrid (Fn) hexaploid;
3. Repeated crossing of the hexaploid hybrid with the octoploid hybrid according to the following scheme: octoploid X hexaploid;
4. Crossbreeding of hexaploid hybrid forms of triticale with wheat according to the following scheme: hexaploid X wheat.

Studies have shown that the effectiveness of these directions largely depends on the initial parental lines involved in the crossing. Using these methods, the various breeding initial material with the traits of different heritability was developed. Judging by long-term (40 years) studies, triticale is used for various purposes in Georgia. Triticale is promising for the extremely different soil and climatic conditions of Georgia. The material produced by us, allows to identify promising silage and grain forms for all zones. Two varieties are certified for distribution in Georgia: a silage variety - Kartli 2, with the biomass yield 50-60 t/ha and a grain variety - Kartli 5, with the grain yield 5.5-6.5 tons/ha.

In Georgia, with the help of triticale has been developed the method of receiving two harvests on one site. The largest amount of triticale biomass is harvested at the beginning of mass heading or flowering. After harvesting the green mass, it is possible to sow the corn, both for silage and grain use (in accordance with the zones). This method has already been developed and basing it, practical recommendations for farmers (1987) was published.

Varieties of silage Triticale are damaged by lodging. To avoid this, along with triticale was sowed peas, which resulted in the decreasing of lodging, and the increasing the quality of the biomass. The use of acquite (grass under snow) in triticale grain and silage varieties

is recommended. Studies have revealed that after harvesting green mass, triticale is characterized by good acquittability. The use of acquite is so effective that in addition, 20-25% of the grain yield can be produced. After the use of acquite method, grain-silage variety Kartli 5 yields 2.0 t/ha grain. This method can be used for autumn sowing. Based on the detailed analysis of the materials available in the literature and obtained by our many years research, the following main conclusions of a breeding and genetic nature can be drawn:

It has been established that modern varieties of the young, from the evolutionary point of view triticale cultivars, are complex hybrid populations and vary from each other by the duration of growing period (they are generally later maturing than wheat). In all cultivars of triticale, compared to wheat, the phases of grain formation and maturation are longer. The period of these growing phases coincides with the dry winds dominant in eastern Georgia, due to which grain crops, including triticale varieties, are forced to mature earlier. Therefore, the determination of the duration of the growing season of existing triticale varieties and the selection of early forms should be carried out in accordance with the timing of heading. It has been determined that existing forms of triticale, according to phenotypic duration, as well as elements determining yield, are very complex populations. By individual selection, it is possible to create a new breeding initial material for receiving varieties of intensive types of food and grain direction. For example, triticale varieties of food direction Kartli 2, Kartli 5 had been approved for the distribution, as well as creation of promising varieties Kartli 1, Kartli 3 and Kartli 4. It has been determined, that there was no correlation between the height of triticale cultivars and the resistance to lodging. Among triticale varieties, such forms have been identified that are characterized by both high growth and resistance to lodging. It was established that all triticale varieties show absolute resistance to yellow and brown rust, a small number of individuals suffered leaf spot. The best donor varieties for breeding in this direction are the following forms of triticale: K-396027, K-430426, K-424448, K-436656, K-4420201, K-588477, K-44919, K-095314, To - 468748, Prague. 25/2, Prague. 57/2, K-442290, K-468748, K-455485, as well as wheat Kartlicum (Dika variety 9/14). The general patterns of the biology of triticale flowering, self-pollination, influence of pollination regime and the time identified in the study, are as follows:

In strict self-pollination of hexaploid triticale, the number of grain per head decreases by 14.6%, in octoploid forms by 7.4%, in wheat by 5.6%. Compared to this type of pollination, in forced and limited-free pollination, the number of grains per head increases, and compared to natural pollination, this figure decreases by 12.3% in forced self-pollination and by 9.6% in limited-free self-pollination. The number of grains in triticale heads in pollination with the use of the method of group isolation of heads is close to free pollination, so this method of pollination can be successfully used to maintain the varietal purity;

Hexaploid triticale in free pollination in terms of the number of seeds per spike is close to hexaploid wheat, and lags behind in pollination in natural conditions. Single and repeated self-pollination of triticale leads to a decrease in plant height, productive tillers, spike length, number of spikelets and flowers in the spike, grains in the head, weight of one head, of one plant and weight of 1000 kernels. Forced self-pollination inside the flower is more suppressing, than self-pollination inside the head. With prolonged controlled pollination (Zh-1- Zh-4), the tendency to inzucht depression of all traits of the plant is revealed. In free pollination of castrated flowers, triticale seed sets are more abundant than wheat.

In early varieties and forms of triticale, pollen bags and pollen grains mature earlier than in later forms. Therefore, the best time to perform castration is when the pollen bags turn slightly yellow. Heads of all triticale forms are distinguished by longer flowering. The flowering of one head of the hexaploid triticale ends in 6-11 days. Late forms and varieties of triticale and wheat are characterized by relatively long period from heading to flowering. Their pestle keeps the viability for 14 days from the moment of castration, medium early breeds- for 12 days, early breeds- for 10-11 days. Triticale pollination can be carried out on the second - seventh days after castration, and pollination of wheat on the second and fifth days.

In interspecies crossing of triticale, the percentage of seed sets of hybrid grains is lower than in interspecies crossing. There is a particularly big difference between direct and reverse crossing. When pollinating castrated octoploid triticale flowers with pollen grains of hexaploid triticale, the percentage of seed sets of hybrid grain yield ranges from 23 to 29%, and when crossed back, this figure is significantly reduced (3-20%); With interspecies crossing of triticale (triticale X soft wheat), the tying of hybrid grains is highly dependent on the pollination time of the castrated flowers. Octaploid triticale pollination is best on the 5th-7th day after castration and onthe 4th-6th day at reverse crossing; When taking hexaploid triticale as the female parent, pollination with pollen of soft wheat is most favorable on the 3rd-5th day after castration, and with reverse crossing, the difference in pollination timing is insignificant; When crossing hexaploid triticale with native varieties of soft wheat, the percentage of hybrid seed sets is high if wheat is taken as the female parent, and in the case of crossing octoploid triticale with soft wheat, the pattern changes. Hybrid seed sets is higher when pollinating octoploid triticale with pollen grains of soft wheat; Octoploid forms of triticale are more difficult to cross with Georgian soft wheat varieties than hexaploid ones, which should be explained by the difference in chromosomal constitution; When crossed with forms of octoploid triticale from different countries, each soft wheat variety reveals different abilities. The following varieties of soft wheat are selected as good breeding components for them: Dzalisura, local Tsiteli and Tetri Doli, Akhaltsikhis Tsiteli Doli and Lagodekhis Grdzeltavtava; The following varieties of soft wheat are distinguished by their high ability of hybridizing with hexaploid triticale: Tbilisuri 5, Mukhranula 7, Akhaltsikhis Tsiteli Doli, Khulugo, Dolispuri 35-4 and Dolispuri 18-46; Varieties of Mexican, American, Hungarian, Russian and Ukrainian selection are distinguished by high ability of hybridizing with Georgian soft wheat varieties. They are

hybridizing with the Ethiopian, Dutch, Greek and Swedish triticale forms with difficulty.

In the second generation are segregated the transgressive forms, which makes it possible to select between plants and donors for further selection by individual characteristics. In addition, among the selected highly fertile plants, are the sterile and those plant species that according to morphological characteristics and varietal affiliation differ from the original forms, namely: wheat turgidium type, wheat compactum type, spelt type, speltiform type and the type of plants of the first generation.

In hybrids of the first and second generations, received as a result of crossing ecologically and geographically remote varieties of hexaploid triticale with the same number of chromosomes, traits of parental forms are inherited with different strength and the level of heterosis is also different. One or the other trait is more dominant in such hybrids where as a female parent are used forms of triticale with a high index of this trait: K-424445, K-43645, AD-201, AD-206. It has been determined that:

By adaptation, hybrids exceed less adaptive parents. Adaptation is more dominant in such hybrids, where the varieties of Georgian, Russian and Ukrainian breeding were used as a female parent. Such traits as early maturity, disease and lodging resistance, are more prevalent in hybrid population where the breeds and forms with high level of these traits were used as a female parent. According to the main elements that determine productivity, higher level of true heterosis is observed in those hybrids where ecologically and geographically remote variety or specie of intensive type is used as a female parent.

In the second generation, sterile and semi-sterile plants are segregated. Segregated plants by head type are similar to native varieties, including transitional varieties, as well as varieties that differ from the native ones in terms of morphological characteristics involved in crossing, including: hard and soft wheat varieties, types of wheat turgidum and compactum, types of wheat spelt and speltiforme, rye type, shriveled, square, very hard and flat-headed plants. Segregated forms of second generation include: very tall and short plants, short stem plants, characterized by the level of productive stem, head length, shape, fertility and grain number, weight of one head and weight of thousand kernels. Based on these traits, we were able to receive a new selection initial material of the food and grain direction from the transgressive forms. In interspecific triticale hybrids of the first generation, heterosis is revealed according to such traits as: productive tillers per plant, spike length and the number of developed spikelets per spike. The inheritance is intermediate: according to the number of seeds per spike, the weight of one head and weight of thousand kernels. At the same time, grains are shriveled and less viable. To obtain relatively high-yielding combinations, crossing should be carried out according to the following scheme: octoploid Triticale X hexaploid Triticale.

In the second generation, the genotypic complexity of the initial material in interspecies triticale crosses gives a very various material in terms of morphological, biological and productive indicators, namely. According to morphological and production characteristics, the following types of plants are received: plants of the original parents types, types of rye, soft wheat, hard wheat, plants such as wheat-turgidum and wheat compactum, plants with intermediate traits, plants of sterile type and type of the first generation, highly fertile plants and such plants that die in different phases of growth and development. Segregated plants vary by individual elements of productivity: transgression is less noticeable in productive tillers, plants similar to both parents and intermediate types are segregating. The process of development of varieties according to the head length and shape is a complex process and in the second generation of hybrid populations are received plants: 1) long and shriveled, with multiple spikes, 2) long and hard, with multiple spikes, 3) short and hard, with small spikes. In the hybrid population plants of this type range from 30 to 40%.

The development of varieties according to the number of grains per spike is a long process. The number of grains per spike of the segregated varieties varied from 2 to 100. The plants varied greatly by the weight of grain of one head, which ranged from 0.2 g to 7.5 g. In terms of completion, color and consistency of grain, plants were selected: 1) with incomplete, powdery and white grains, 2) with incomplete, with semi-horny and red grains, 3) with incomplete, powdery and white grains, 4) with semi-porous, semi-horny and red-colored grains, 5) full, with powdery and white grains, 6) full, with semi-horny and white grains, 7) full, with horny and red grains, 8) full, with horny and white grains. By interspecies hybridization of octoploid and hexaploid triticale in the second and following generations are obtained highly productive, compared to the original parents and wheat itself, hybrids of hexaploid forms (the so-called secondary triticale). It has been determined that:

The increase in productivity of the hybrid plant of hexaploid triticale obtained by crossing octoploid triticale with hexaploid triticale is caused by the variability of A and B genomes existing in the genotype of the original forms of soft and hard wheat, by the phenomenon of positive transgression and by the influence of rye genomes. The high productivity of the hybrid of hexaploid triticale is formed on the basis of genes that transfer multiple heading of rye, multiple flowering of wheat spike and large grains.

For the further breeding improvement of hybrids of hexaploid triticale (i.e. secondary hexaploid triticale) the following types of crossing schemes can be employed:

- Crossings of octoploid triticale with hexaploid: octoploid X hexaploid;
- Interhybrid crossings: hybrid (Fn) of hexaploid X hybrid (Fn) of hexaploid;
- Repeated crossings of hexaploid hybrid with octoploid hybrid according to the scheme: Octoploid X Hexaploid;
- Hybrid of hexaploid triticale X soft wheat.

When studying hybrids of the first and second generations obtained

from the crossings of triticale and soft wheat, a number of patterns have been established for the use in triticale breeding:

Triticale as an intergeneric amphidiploid and intergeneric heterozygous organism, has a tendency to cross-pollination, and as a result, existing variety samples are complex populations. Therefore, in the variety samples selected for crossing, individual selection of plants should be carried out according to the complex of traits, both for castration and in the case of using them as a pollen parent. When selecting varieties for breeding with the goal of increasing the grain yield, it should be taken into account that the grain yield is determined by the number of grains of one plant and the weight of grains per spike. Therefore, plants for crossing should be selected from the harvest of optimal density with big grain weight. Varieties of hexaploid triticale of Mexican breeding are the best components for crossing with soft wheat to obtain a new selection initial material of a highly productive grain direction, and for creating varieties for food purposes, hexaploid and octoploid forms of Ukrainian selection give good results, as well as the varieties and forms of hybrid of hexaploid and octoploid triticale created by us; At crossings of octoploid and hexaploid triticale, as well as hybrids of octoploid and hexaploid triticale, the following varieties of soft wheat of Georgian origin are distinguished: Dolis Puri 35-4, Akhaltsikhis Tsiteli Dolis Puri and heterozygous forms of soft wheat Tbilisuri 5, Mukhranula 7, Tbilisuri 8 reveal high specificity and general combination ability. For the improving the quality of triticale grain , the variety of soft wheat Akhaltsikhis Tsiteli Dolis Puri should be used in crossing.

The best donor- variety for the increasing the fertility of triticale is the selection variety of soft wheat Dolis Puri 35-4, and the donor- varieties for productive tillers are: Dolis Puri 18-46, Dolis Puri 35-4, Tetri Ipkli, Corboulis Dolis Puri; For the receiving of new breeding initial material with the possibility of creating early heading varieties of triticale, the best donor - varieties are soft wheat varieties: Tbilisuri 5 and Mukhranula 7, as well as triticale varieties of Mexican, Ethiopian and Georgian breeding. In the second group of hybrids received by crossings of triticale with soft wheat, the plants of following main types are obtained: a) type of soft wheat, b) type of hard wheat, c) rye type, d) type of triticale, d) triticale with traits of soft wheat, e) soft wheat with traits of triticale, g) similar to the first generation, h) plants of different type, and) sterile plants, l) semi-sterile plants. In addition, the following types of wheat are obtained: turgidum wheat, compactum wheat, spelt and speltiform. The selected plants differ from each other in the length of the spikelet, the shape of the spikelet, hardiness, completeness, awns, color, etc. Among them are interesting plants, with the traits of both genera. Triticale plants are characterized by the development of a short spike keel, a round, short and compact spike. Wheat-type plants are characterized by a long and shingled spike, shriveled, difficult to thresh. It has also been determined that: In the third and subsequent generations, various forms are not developed. Are segregating the biotypes with intermediate traits. Segregation continues in the F4 and F5 generations resulting in the formation of the negative transgressive forms, so selection in hybrids of this group should be carried out in the F2 and F3 generations.

As a result of the mutual crossings of the octoploid and hexaploid forms of triticale, as well as of their crossings with of soft wheat, in the second generation of triticale hybrids, were received new types of plants with "hybrid dwarfism" unknown to the science. This new type plants are not characterized by simultaneous forming of tillers. In such plants, tillers are growing in the following order: after the first tillers, appear the second ones, after the second - the third, and so on. In addition, unlike the typical plant with "hybrid dwarfism," all tillers of this new type of "hybrid dwarf" are more or less fertile. Non-simultaneously developed stems are characterized by an uneven growing period and are unsuitable for selection. For the receiving of triticale varieties of intensive type for food direction, the use of octoploid triticale in breeding is promising, individual selection in the received hybrid generations, their sowing in rows and studying. During 16 years of work in the collection and hybrid nurseries, 31,573 lines has been studied, which has been considered promising for the grain and food direction, and the best of them (2,451 lines) were studied in the check nurseries. When studying the grain yield, it was determined that.

The average yield of cultivars of grain triticale in check nursery ranges from 4.18 t/ha to 6.5 t/ha (check Bezostaia 1-5.1 t/ha), and the biomass of forage forms - from 49.6 t/ha to 72.4 t/ha. In the preliminary variety test, the average yield of grain varieties of triticale ranged from 5.7 t/ha to 6.9 t/ha, and the average yield of biomass of forage triticale ranged from 71.0 t/ha to 80.6 t/ha, yield of check varieties was 53.0 t/ha and 49.7 t/ha, respectively.

In testing of competitive varieties, the average grain yield of promising triticale varieties ranged from 5.5 t/ha to 6.6 t/ha, and the average biomass yield of promising triticale forage varieties ranged from 69 to 93.0 t/ha. The new initial material created by us, along with the theoretical value, has breeding and practical value for poroducing new varieties. At the same time, special attention should be paid to the early ripening, disease-resistant, lodging resistant, high-yielding forms with complete kernels, high protein concentration in the grain and lysine in the protein. It has been established that with interspecific and intergeneric crossings of triticale, it is possible to create a completely new initial material from a botanical and selection-genetic point of view. Even for the production of triticale and wheat of modern type.

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