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Genetics And Selection

Intraspecific Genetic Heterogeneity of Tetraploid Wheat Species Dika (*T. carthlicum* Nevski) according to Short-Stem Genes

Petre Naskidashvili*, Maka Naskidashvili, Ia Naskidashvili**, Nikoloz Gakharia****

* *Academy Member, Georgian State Agrarian University, Tbilisi*
** *Georgian State Agrarian University, Tbilisi*

ABSTRACT. It has been established by studying F1-F2 generations obtained as a result of crossing three main varieties (var. stramineum, var. rubiginosum, var. fuliginosum) of tetraploid wheat species Dika (*T. carthlicum* Nevski) with Georgian varieties (var. striatum, var. reichenbachii, var. coerulescens, var. chvamlicum) of other tetraploid species (*T. turgidum L., T. durum* Desf, *T. georgicum* Dek.), that varieties of Dika wheat (*T. carthlicum*) are genetically heterogenous according to short-stem genes. Besides, it became clear that inheritance of short-stem trait can be both oligogenic and polygenic. Non-allelic influence connected with two or four loci is a case.

Key words: *oligogenic inheritance, polygenic inheritance, allele, genotype*

Introduction

Analysis of data presented in scientific literature clearly shows that in the case of irrigation and application of high doses of mineral fertilizers lodging of high-stem wheat varieties takes place, essentially reducing the grain harvest and its quality. Thus, breeding of high productive short-stem wheat varieties and their implementation in practice is assumed as one of the most significant preconditions for intensification of agriculture.

Part of wheat varieties in the global gene pool possess an oligogenically determined short-stem trait. Japanese varieties Akagomugi and Norin 10 bear in their genotypes genes that determine short-stem trait. Industrially productive varieties (Ardito, Mentana, Gainess, Bezostaya 1 and others) have been bred in Italy, Mexico, USA and other countries using these varieties. These varieties contributed much to the development of wheat breeding in the world.

In all wheat producer countries worldwide interest in breeding of short-stem varieties still remains growing. That is why short-stem plants, segregated in hybrid generations obtained by means of intraspecific crosses, are of great theoretical and practial significance. Besides, this enriches the world gene pool of short-stem varieties and they can be used as initial material to breed short-stem varieties of intensive type.

The present paper presents the results of a study of hybrids obtained by means of reciprocal crossing of three main varieties of Dika wheat (var. stramineum, var. rubiginosum, var. fuliginosum), variety striatum of hard wheat *T. turgidum*, varieties of hard wheat (var. reichenbachii and var. coerulescens) and the variety chvamlicum of Georgian wheat *T. georgicum*.

Materials and methods

Seeds of varieties listed in the introductory part of the paper were obtained from the department of genetics, breeding and seed-farming of the Georgian State Agrarian University.

Hybrids were obtained using the method of free-limited pollination [1]. To get each hybrid combination 200-200 flowers were castrated and pollinated. A total of 720 hybrid grains of 12 direct and reverse combinations were obtained. The set of hybrid grains totalled 30% on the average.

Hybrid grains were sown manually, in autumn, in conditions of irrigation. Soft wheat variety Bezostaya 1, the variety Dika 5/14 of Dika wheat and the variety of hard wheat coerulescens 19/28 were used as standard varieties. Hybrids were grown in conditions of best agricultural techniques. Observations and assessments of experimental plots were performed according to approved methods. All experiments were carried out at Mukhrani training-experimental farm (Kartli, village of Mukhrani, Mtskheta district, Eastern Georgia).

Results and discussion

Tetraploid intraspecific crosses were performed normally. Plants of the first generation of all hybrid combinations developed well. In none of the combinations were hybrid necrosis, hybrid chlorosis and white-spotted chlorosis revealed and in some hybrid combinations the phenomenon of hybrid dwarfism was noticed.

Signs of rust diseases were not found on plants of the first generation, nor were cases of infection with smut detected. In all combinations of the first generation the phenomenon of heterosis was evident in stem height, tillering and mass of 1000 grains. Stem height of parental forms varied within the range of 110-155 cm.

Short-stem plants were detected in hybrid populations of all combinations of the second generation obtained as a result of reciprocal crossing of Dika wheat (T. *carthlicum*) with T. *turgidum*, hard wheat or T. *georgicum*. According to stem height plants segregated in the second generation were divided into groups of high-stem and short-stem plants. Stem height of short-stem plant group varied within the range of 40 cm-95 cm and height of high-stem plants was more than 110 cm. Some plants of the short-stem group were distinguished for big and well filled dense spikes.

Short-stem plants segregated in the second generation obtained as a result of crossing three varieties of Dika wheat (var. stramineum, var. rubiginosum, var. fuliginosum) with variety of T. *turgidum* (var. striatum), varieties of hard wheat T. *durum* (var. *reichenbachii* and var. *coerulescens*) and T. *georgicum* var. chvamlicum were different. In crossings, where the white-spiked variety of T. *carthlicum* - var. stramineum participated, the share of short-stem plants was greater than in crosses obtained with participation of other varieties of T. carthlicum - (var. rubiginosum, var. fuliginosum) (Table 1). Results were similar in reciprocal crosses.

Greater share of short-stem plants in combinations obtained from crosses of *T. carthlicum* var. stramineum with *T. turgidum* (var. striatum), *T. durum* (var. reichenbachii, var. couerulescens) or *T. georgicum* (var. chvamlicum) was explained by the hypothesis of J.B. Piech and L.E. Evans [2]. The authors of this hypothesis propose that short-stem trait is controlled by a dominant gene and inhibitor dominant gene, and short-stem plants are obtained when the gene-inhibitor is in a recessive state or when it is absent.

If we mark the dominant gene that is responsible for short-stem trait manifestation by the letter "B" (the first letter of the Latin word breviacumitas– short-stemmed), then according to the proposed hypothesis, the genotype of *T. carthlicum* var. stramineum may be expressed by the formula BBII, and the genotypes of the varieties of the same species var. rubiginosum, var. fuliginosum, of the wheat *T. turgidum* var. striatum, varieties of hard wheat var. reichenbachii and var. coerulescens as well as var. chvamlicum of *T. georgicum* may be expressed as bbii.

According to this hypothesis, the ratio 13 high-stem and 3 short-stem plants is anticipated, but in our experiment when using the varieties var. rubiginosum and var. fuliginosum of *T. carthlicum* wheat in crosses, in whose genotype the recessive genes bbii are present, segregation of high-stem and short-stem plants made up the ratio 15 (high-stem) :1 (short-stem).

The results presented in Table 1, in particular segregation of hybrids obtained as a result of crossing *T. carthlicum* var. stramineum with *T. turgidum* (var. striatum), hard wheat (var. reichenbachii, var. coerulescens) and *T. georgicum* (var. chvamlicum) cannot be explained only on the basis of the hypothesis of J. B. Piech and L. E. Evans., as according to this hypothesis, in order to get segregation at a ratio 13:3, the partners chosen for crossing with *T. carthlicum* var. stramineum should have the genes bbii in their genotypes. Then in crosses of *T. carthlicum* var. rubiginosum and var. fuliginosum, whose genotypes contain bbii genes are present, with partner carriers of the same genes, segregation at the ratio 15:1 seems to be inexplicable.

With a view to explaining the results of crossings additionally the hypothesis of M. P. Naskidashvili [3] was applied along with the hypothesis of J. B. Piech

Table 1

Segregation into high- and short-stem plants in the second generation of different hybrid combinations

Hybrid combination	Anticipated ratio of high-stem plants to short-stem ones	Segregation		x^2	
		Real	Anticipated	Calculated	Anticipated
1. *T. carthlicum* var. stramineum x *T. turgidum* var. striatum	12.2:3.8	247:53	229:72	5.97	3.84
2. *T. carthlicum* var. stramineum x *T. durum* var. reichenbachii	12.2:3.8	280:70	267:83	2.76	3.84
3. *T. carthlicum* var. stramineum x *T. durum* var. var. coerulescens	12.2:3.8	240:50	223:47	3.07	3.84
4. *T. carthlicum* var. stramineum x *T. georgicum* var. chvamlicum	12.2:3.8	243:57	226:74	5.87	3.84
5. *T. carthlicum* var. rubiginosum x *T. turgidum* var. striatum	15.0:1.0	270:10	263:17	3.07	3.84
6. *T. carthlicum* var. rubiginosum x *T. durum* var. reichenbachii	15.0:1.0	283:17	281:19	0.22	3.84
7. *T. carthlicum* var. rubiginosum x *T. durum* var. coerulescens	15.0:1.0	280:20	277:23	0.26	3.84
8. *T. carthlicum* var. rubiginosum x *T. georgicum* var. chvamlicum	15.0:1.0	240:30	230:40	0.29	3.84
9. *T. carthlicum* var. fuliginosum x *T. turgidum* var. striatum	150.0:1.0 ?	273:22	277:18	0.95	3.84
10. *T. carthlicum* var. fuliginosum x *T. durum* var. reichenbachii	15.0:1.0	360:20	356:24	0.71	3.84
11. *T. carthlicum* var. fuliginosum x *T. durum* var. coerulescens	15.0:1.0	279:21	276:23	0.78	3.84
12. *T. carthlicum* var. fuliginosum x *T. georgicum* var. chvamlicum	15.0:1.0	229:26	225:30	0.86	3.84

and L. E. Evans. According to the hypothesis propered by M. P. Naskidashvili, there are two more loci responsible for plant height, which are not tied to B and I loci and phenotypically are expressed independently from B and I. If, according to this hypothesis, we mark these genes by X and Y, short-stem trait is manifested by means of specific complementation of recessive alleles xxyy in homozygote. All the other genotypes are high-stemmed.

According to the hypothesis of M. P. Naskidashvili, the formulas of crossings may be expressed as follows:

1st cross:

T. *carthlicum* var. stramineum x *T. turgidum* (or *T. durum* or *T. georgicum*)
BBiiXXyy x bbiixxyy

2nd cross:

T. *carthlicum* var. rubiginosum or var. fuliginosum *T. turgidum* (or *T. durum* or *T.georgicum*)
bbiiXXyy x bbiixxYY

In short-stem genotypes segregated in the first cross the following alleles are present: B-ii plus any x or y allele; and any of allele B and I plus xxyy. In the second cross bbiixxyy genotype is present. In the second cross segregations make up 15:1. The segregation ratio obtained in the first cross is different from the ratio 13:3 and will be equal to (3/16+1/16) – (3x1) (16+16) =3.8. The ratio of high- and short-stem plants is 12.2: 3.8.

If we sum up the share of short-stem genotypes according to loci B, I, X and Y and subtract from it the share of short-stem plants got from the first two and last two loci, the obtained new ratio does not differ significantly from the ratio 13:3. That is why the calculated x^2 corresponds to the 12:3 segregation ratio and 12.2:3.8 segregation ratio as well.

Thus varieties of Dika wheat (*T. carthlicum*) are heterogenous according to the genes responsible for the height of plant stem. Short-stem plants, got as a result of using the varieties of Dika wheat in crosses, can be used for breeding varieties resistant to lodging. They seem especially prospective for obtaining varieties of intensive type of tetraploid species.

Poor crossability of varieties of Dika wheat and their hard separation from each other was marked long ago by P. M. Zhukovsky, who first described these varieties [4]. Later these data were proved by M. M. Venediktov [5], P. P. Naskidashvili [6] and other scientists.

According to L. L. Dekaprelevich [7], var. stramineum of Dika wheat was mainly found in plantings of var. rubiginosum as admixture and pure plantings of var. stramineum and mix of var. stramineum with soft wheat were found in Dusheti and Mtkheta districts. Besides that L. L. Dekaprelevich points out that the variety fuliginosum of *T. carthlicum* is singled out from other varieties. It was distributed on the main range of the Greater Caucasus and Daghestan. Varieties stramineum and rubiginosum were distributed in South Georgia and found also in Armenia.

გენეტიკა და სელექცია

ხორბლის ტეტრაპლოიდური სახეობა დიკას სახეობისშიდა გენეტიკური არაერთგვაროვნება მოკლეღეროიანობის გენების მიხედვით

პ. ნასყიდაშვილი*, მ. ნასყიდაშვილი, ი. ნასყიდაშვილი**, ნ. გახარია****

** აკადემიის წევრი, საქართველოს სახელმწიფო აგრარული უნივერსიტეტი*
*** საქართველოს სახელმწიფო აგრარული უნივერსიტეტი*

ხორბლის ტეტრაპლოიდური სახეობის — დიკას (*T. carthlicum* Nevsky) სამი ძირითადი სახესხვაობის (var. stramineum, var. rubiginosum, var. fuliginosum) სხვა ტეტრაპლოიდური სახეობების (*T. turgidum* L., *T. durum* Desf., *T. georgicum* Dek.) სახესხვაობების (var. striatum, var. reichenbachii, var. coerulescens, var. chvamlicum) ქართულ ფორმებთან შეჯვარებით მიღებული F_1-F_2 თაობების შესწავლით დადგინდა, რომ ხორბლის სახეობა დიკას (*T. carthlicum*) სახესხვაობები გენეტიკურად არაერთგვაროვანია მოკლეღეროიანობის გენების მიხედვით. ამასთან ერთად გამოირკვა, რომ მოკლეღეროიანობა მემკვიდრეობს როგორც ოლიგოგენურად, ასევე პოლიგენურად. ადგილი აქვს ორ ან ოთხ ლოკუსთან დაკავშირებულ არაალელურ ზემოქმედებას.

REFERENCES

1. *P.P. Lukyanenko* (1979), Izbrannye trudy. Selektsiya i semenovodstvo ozimoi pshenitsy, M., p. 52 (in Russian).
2. *J. Piech, L.E. Evans* (1967), Inheritance of dwarfing crosser of Spring Wheat varieties. Genetica Polon. (Warsaw-Poznan) 8: 1-7.
3. *M.N. Naskidashvili* (2005), Izvestiya Timiryazevskoi sel'skokhozyaistvennoi Akademii. Issue 3, July-September, Moscow, 116-121 (in Russian).
4. *P.M. Zhukovskii* (1971), Kul'turnye rasteniya i ikh sorodichi, L., 752 p. (in Russian).
5. *M.M. Venediktov* (1959), Abstract of Candidate Thesis. N. Vavilov's All-Union Scientific-Research Institute of Plant Breeding, 19 p. (in Russian).
6. *P.P. Naskidashvili* (1983), Mezhvidovaya gibridizatsiya pshenitsy. M., p. 119 (in Russian).
7. *L.L. Dekaprelevich* (1954), Proceedings of the Institute of Field-crop Cultivation of the Georgian Academy of Sciences, v. VIII: 16 (in Russian).

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