Bulgarian Journal of Agricultural Science, 14 (No 4) 2008, 390-396
Agricultural Academy

WINTER TRITICALE AD-17-B (2n=6x=42) – A MAIN DONOR OF GENES FOR SHORT STEM, LONG SPIKES, HIGH PROTEIN CONTENT IN GRAIN AND PROGRESSING MEIOSIS STATUS OF PMC

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Abstract

TSVETKOV, St. M., 2008. Winter triticale AD-17-B (2n=6x=42) – a main donor of genes for short stem, long spikes, high protein content in grain and progressing meiosis status of PMC. *Bulg. J. Agric. Sci.*, 14: 390-396

A new original triticale AD-17-B (2n=6x=42) was developed: carrier of genes for short stem (75-80 cm), incomplete dominant inheritance of plant height in F_1 (degree of dominance d/a from +0.41 to +0.54), long spikes (17-18 cm) – inheritance of spike length in F_1 was incomplete dominant towards the parental component with longer spikes (degree of dominance d/a from +0.34 to +0.75), high protein content in grain (18-19 %) – dominant inheritance in F_1(degree of dominance d/a from +0.90 to +1.09), peculiarities of PMC meiosis – winter triticale AD-17-B (2n=6x=42) had the lowest mean percent of PMC meiosis disturbances (44.66 %), that of the Mexican triticale AD-No 6 (2n=12) (Armadillo) being 55.51 %, considered to be one of the greatest breeding achievements of CIMMYT (Mexico) with high spike fertility.

Key words: triticale (2n=42), donor of genes, short stem, long spikes, protein, meiosis

Introduction

Triticale is a new cereal crop and many problems related to its breeding have not yet been sufficiently clarified. Little is known of the varieties carrying genes for important breeding characters. The experimental data on the types of heritability of the breeding characters in the individual varieties, the significance of the direction of crossing, and the role of the mother form for formation of the new quality in the variety are scarce.

During the recent years, similar to wheat [(variety Tom PouceBlanc (Rh3), carrier of genes for short stem (McIntosh, 1976)], in triticale, too, there are initial experimental data on triticale varieties carriers of genes for important breeding characters. Very successful was the work of Kish (1975), on registering the short-stemmed triticale Bocolo (Rht3) as carrier of genes for short stem. Of special interest are the investigations of Rao and Joshi (1979) who established the reciprocal effect. A radical turning point was achieved in CIMMYT, Mexico, with the development of the unique variety Armadillo – one of the greatest achievements in the field of wheat-rye amphidiploidy. Later Gustufson and Zillinsky (1973) found out that in variety Armadillo the wheat chromosome 2D was successfully substituted with the rye chromosome 2R.

This paper, based on reciprocal crosses and the use of convenient mathematical methods (Mather, 1949), reports original data on winter triticale AD 17-

B (2n=6x=42) as a variety-carrier of genes for 4 main breeding characters (short stem, long spikes, high protein content in grain and progressing PMC meiosis in F_1).

Material and Methods

Winter triticale AD 17-B (2n=6x=42) was obtained with the participation of the short-stemmed (dwarf) winter wheat Tom PouceBlanc (Rht3). Plant height of Tom PouceBlanc is 45 cm, and of triticale AD 17-B (2n=42) it is 75-80 cm. This is the first Bulgarian triticale with a relatively short stem (75-80 cm) and very good grain number per spike (65 grains), and high protein content in grain (19 %). It is a wonderful donor for combining breeding. It possesses progressing status of PMC meiosis.

The analysis on the peculiarities of MPC meiosis was carried out on temporary preparations through squashing of the material (Tsvetkov, 1982). The mathematical processing of data was done according to Molostov (1965) and Mather (1949).

Results and Discussion

It is a rare case in triticale breeding work to have varieties, which, at the initial crossing with other suitable parental components, allow in F_2 and later progenies to carry out selection simultaneously on several breeding characters (short stem, long spikes, high fertility, high protein content in grain and progressing status of PMC meiosis). In our experimental work winter triticale AD 17-B (2n=6x=42) was this type of variety.

Morphological Description and Systematic Affiliation

Winter triticale AD 17-B (2n=6x=42), by the construction of its status – stem, spike and leaves, belongs to the short-stemmed varieties highly promising as donors for breeding. Stem is relatively short (with 92 cm shorter than that of variety Danae) thick, strong and resistant to lodging (Figure 1).

Spikes are long, without pilosity, with medium thickness of spikelets. They have short awns. Leaves are long, broad, dark-green and slightly bent. The ligule at the base of the last leaf is yellow. It is completely resistant to powdery mildew and highly resistant to leaf rusts. This high resistance to diseases was confirmed in artificial infection field, as well.

By its systematic affiliation it belongs to the typical short-stemmed 42-chromosome triticale type (X Tricosecale Wittmack).

Fig. 1. Short-stemmed triticale AD-17-B (2n=42) with very long spikes against the background of long-stemmed rye Danae (DAI - General Toshevo)

Heritability of the Main Productivity Elements in F_1. Plant Height

According to Shulydin (1979) intervarietal (homoploid) hybridization in triticale is a scientific problem of the present and the future. The history is very short. Therefore the experimental data on plant height heritability in F_1 are rather scarce and quite contradictory in individual cases. Shulydin (1979) reported intermediary heritability in crossing Hungarian short-stemmed triticale to Harkov medium-high triticale,

Table 1
Parameters of plant height in short-stemmed triticale AD-17-B /2n=42/ and hybrids in F1

Parents and hybrids	Heritability x +sx	Degree of dominance (d/a)
Short-stemmed parental varieties		
AD-17-B	78.78 + 0.32	-
Parents with medium-high stem		
AD-durum form	158.00 + 2.01	-
AD-206	133.09 + 1.36	-
Hybrids and heritability in F_1		
AD-17-B x AD-durum form	143.63 + 1.49	+0.42
AD-durum form x AD-17-13	143.36 + 1.55	+0.54
AD-17-B x AD-206	123.02 + 1.24	+0.51
AD-206 x AD-17-B	125.13 + 1.27	+0.41

while Baeva and Georgieva (1980) pointed out cases of dominant and super-dominant heritability.

The data in Table 1 shows that at reciprocal crossing of the short-stemmed triticale AD 17-B (2n=6x=42) to the medium-high triticale AD-durum form (2n=42) and AD-206 (2n=42), the inheritance of plant height in F_1 was towards the parent with higher stem. It was established that the degree of inheritance (d/a) of plant height in F_1 on reciprocal basis was incomplete dominant with indices from +0.41 to +0.54. Based on the opinion of MacIntosh (1976) we have reasons to point out that that the short-stemmed variety AD 17-B (2n=42) carries the semi-dwarf gene *Rht3* for short stem and selection for short stem after F_2 is very promising.

No significant differences were registered in plant height heritability in F_1 on reciprocal basis. The differences obtained were very small and were not mathematically significant especially in the reciprocal crosses AD 17-B (2n=42) x AD 206 (F_1=125.1±1.24) and AD-206 x AD 17-B (F_1=125.1±1.27) (Table 1).

Length and Number of Grains per Main Spike

Spike length is of primary importance in triticale productivity since this character, in combination with the other quality indices, determines to a large extend the production potential of the variety. There are two opinions in breeding concerning this aspect: 1) long spikes, good fertility and reduced tillering capacity; and 2) medium long spikes, good fertility and increased tillering capacity.

Table 2 presents the short-stemmed triticale AD 17-B (2n=42) with long spikes and the medium long-stemmed triticale AD-durum forme (2n=42) and AD-206 (2n=42) with medium long spikes. Hybridization was in practice carried out between triticales highly contrasting by spike length. The analyses on the F_1 hybrids showed that spike length heritability is incomplete dominant towards the parental form AD 17-B (2n=42) with longer spikes (degree of dominance d/a from +0.34 to +0.75). This allows to point out that short-stemmed triticale AD 17-B (2n=42) carries recessive genes for long spikes.

No significant differences were found out in spike length on reciprocal basis. The differences in spike length between the F_2 hybrids and the short-stemmed triticale AD 17-B (2n=42) were negative, and their values mathematically insignificant. The hybrid plants in F_1 were in almost all combinations markedly uniform with regard to spike length (V_c from 0.97 to 2.28 %). In the reciprocal crosses AD 17-B (2n=42) x AD-206 and AD-206 x AD-17-B high pilosity under the spike was dominant in F_1, a character inherited

Table 2
Parameters of length and number of grains per spike in short-stemmed triticale AD-17-B (2n=42) and hybrids in F1

Parents and hybrids	Heritability			
	Spike length		Number of grains per spike	
	x+sx	Degree of dominance, d/a	x + sx	Degree of dominance, d/a
Parental varieties with long spikes				
AD-17-B	171.8 + 0.31	-	65.22 + 2.62	-
Parental varieties with medium-long spikes				
AD-durum form	12.40 + 0.29	-	55.63 + 1.34	-
AD-206	11.25 + 0.18	-	53.09 + 1.19	-
Hybrids and heritability in F1				
AD-17-B x AD-durum form	16.85 + 0.17	+0.75	67.77 + 1.83	+1.53
AD-durum form x AD-17-B	16.80 + 0.18	+0.72	67.08 +3.58	+1.39
AD-17-B x AD-206	15.43 + 0.15	+0.34	64.02 +1.67	+0.80
AD-206 x AD-17-B	15.70 + 0.23	+0.43	60.13 + 1.96	+0.33

from AD-206. In hybridization between the short-stemmed triticale AD 17-B (2n=42) with long spikes and the medium long-stemmed triticale AD-durum form (2n=42) and AD-206 (2n=42) with medium long spikes, besides long spikes heritability in F_1, it is also very important what is the grain number per spike. In all four crosses it was found out that heritability of grain number per spike was towards the parental component with higher number per spike AD 17-B (2n=42), although there were two very important peculiarities: in the reciprocal crosses AD 17-B x AD-durum form and AD-durum form x AD 17-B the inheritance of grain number per spike was super-dominant (degree of dominance from +1.39 to +1.53), while in the reciprocal crosses AD 17-B x AD-206 and AD-206 x AD 17-B the inheritance of grain number per spike was incomplete dominant (degree of dominance from +0.41 to +0.51).

Protein Content in Grain

There are few investigations in Bulgaria on heritability of protein content in grain in F_1 in crosses of the same ploidity (Tsvetkov, 1982). Such investigations have been carried out only on crosses with different chromosome number (Hristova and Baeva, 1975).

The experimental data in Table 3 show that the inheritance of protein content in grain of F_1 depends exclusively on the genotype of the components used. It was established that in the reciprocal crossing AD 17-B x AD-206 and AD-206 x AD 17-B the inheritance of protein content in grain was exceptionally towards the parental form AD-206 with lower mean protein percent. In all other reciprocal crosses of AD-Winter with the Mexican triticale AD-No 8 and AD-No 14 heritability of protein content in grain was towards the parental component AD-Winter with higher protein content.

Dominant heritability of protein content in grain was registered in the reciprocal crossing of AD-No 8 to AD-Winter. It was established that the mean protein content in grain in the combinations AD-No 8 x AD-Winter and AD-Winter x AD-No 8 amounted to 18.5 and 18.9 %, that of AD-Winter being 18.7 % and of AD-No 8 – 14.1 %. Heritability was towards the parental component AD-Winter with higher content (18.7 %). Degree of dominance was +0.90 and + 1.09.

Table 3
Protein content in grain in short-stemmed triticale AD-17-B (2n=42), %

Parents and hybrids	Protein and heritability in F_1	
	x + sx, %	Degree of dominance, d/a
Parental varieties with high protein content in grain		
AD-17-B (2n=42)	19.0	-
AD-Winter	18.7	-
Parents with medium protein content in grain		
AD-206 (2n=42)	15.9	-
AD-№8 (2n=42)	14.1	-
AD-№14 (2n=42)	13.1	-
Hybrids and heritability in F_1		
AD-17-B x AD-206	15.60	-1.19
AD-206 x AD-17-B	16.70	-0.57
AD-Winter x AD-№8	18.00	+0.91
AD-№8 x AD-Winter	18.90	+1.09
AD-Winter x AD-№14	18.20	+0.82
AD-№14 x AD-Winter	17.90	+0.71

Incomplete dominant heritability of protein content in F_1 was registered in the reciprocal crossing of AD-No 14 to AD-Winter (degree of dominance +0.71 and +0.81). While protein content in the grain of the parental forms AD-No 14 and AD-Winter was from 13.1 to 18.7 %, the mean protein content in the grain of F_1 in the combinations AD-No 14 x AD-Winter and AD-Winter x AD-No 14 amounted to 17.9 and 18. 2%. The analyses repeated only towards AD-No 14 x AD-Winter confirmed the regular character of incomplete dominant heritability of protein in grain (degree of dominance +0.67).

Progressing Status of PMC Meiosis

Low fertility in triticale is usually related to significant disturbance of PMC meiosis (Muntzing, 1956; Krolow, 1962; Skoles et al., 1974; Hvostova and Shkutina, 1975; Tsvetkov, 1982). There are contradictory opinions holding that no correlation exists between high fertility of spike and cytological stability of meiosis in PMC (Riley, Chapman, 1957; Gustafson, 1976; Kempana, Scetheram, 1972; Boyd, Sissidia, Lalter, 1970).

Table 4 shows the disturbances of the PMC meiosis of the short-stemmed triticale AD-17-B (2n=42); check variants were the American triticale AD-Winter (2n=42) and the Mexican triticale AD-No 6. Only the end results were used to compare the degree of disturbance in PMC meiosis. According to data provided by Gustafson (1976), metaphase I is considered a standard stage since the regularity of the meioses process is best evaluated in triticale. In this respect AD-17-B (2n+42) has the best starting position with 52.51 % disturbances in MI, against 54.63 % for AD-Winter (2n42) and 65.54 % for AD-No 6 (2n=42). These data are rather indicative because the short-stemmed triticale AD-17-B (2n=42) revealed its superiority over triticale AD-No 6 (2n =42), a line from variety Armadillo, one of the greatest breeding achievements of CIMMYT, Mexico and in the world. The cytological analyses carried out showed that the lowest mean percent of PMC disturbances of meiosis is shown by the short-stemmed triticale AD-17-B (2n=42) which amount to 44.66 %, that of Mexican triticale AD-No 6 being 50.51 %, and of the Ameri-

Table 4
Degree of PMC meiosis disturbances in F1 of short-stemmed triticale AD-17-B (2n=42)

Triticale	Stages	
AD-17-B (2n=42)	M_I	52.51
	A_I	44.30
	M_{II}	41.82
	A_{II}	47.65
	T	37.01
AD-Winter (2n=42) (check variant)	M_I	54.63
	A_I	46.65
	M_{II}	56.42
	A_{II}	65.53
	T	34.17
AD-№6 (2n=42) (check variant)	M_I	56.54
	A_I	51.79
	M_{II}	47.40
	A_{II}	40.70
	T	58.16

can triticale AD-winter (2n=42) – 51.48 %. This allows us to point out that triticale AD-17- B (2n=42) is suitable to use not only as a donor for short stem, long spike and high protein content in grain, but also as donor for producing forms with low percent of disturbances in PMC meiosis.

Conclusion

A new 42-chromosome triticale AD-17-B (2n+42) was developed, carrier of genes for:

- Short stem (75-80 cm); plant height heritability in F_1 is incomplete dominant (degree of dominance from +0.41 to +0.54) and therefore this is a short-stemmed triticale AD-17-B (2n=42) as a carrier of the semi-dominant gene Rht3 for short stem;
- Long spikes (17-18 cm): heritability of spike length in F_1 is incomplete dominant towards the parental component with longer spikes (degree of dominance from +0.34 to +0.75). The variety is carrier of recessive genes for long spikes;
- High protein content in grain (18-19 %); heritability in F_1 is dominant (degree of dominance from +0.90 to +1.09) and incomplete dominant (degree of dominance from +0.71 to +0.81), in most cases towards the parental component with higher protein content in grain;
- Peculiarities of meiosis in PMC: winter triticale AD-17-B (2n=42) has the lowest mean percent of disturbances in PMC meiosis (44.66 %) as compared to 51.51 % of Mexican triticale AD-No 6 (2n=42) considered to be one of the greatest breeding achievements of CIMMYT – Mexico with regard to high spike fertility.

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Received December, 2, 2006; accepted for printing January, 25, 2008.