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Genetic identification of wheat resistance genes to yellow rust

Abstract

Resistance to stripe rust of wheat introgression lines with efficient gene Yr isogenic lines in Avocet variety was studied. The lines 344 and 345 had a dominant and monogenic nature of inheritance for resistance to yellow rust. Resistance gene of the line 344 was found to be allelic to Yr 5 gene, but for the line 345, it was found to be allelic to Yr 10 gene of Avocet tester. Those tolerant to yellow rust introgressive lines could be widely used as donors of stability in practical selection of soft wheat.

Key words: Introgressive line, wheat, species, genetic analysis, hybridization, resistance to yellow rust (Yr).

Introduction

Creation and intensive use of soft wheat donors in the selection processes with effective resistance Yr genes, transferred from wild relatives, could significantly contribute to their genetic implementation regarding a single or multiple economically-valuable trait [1-4]. The tetraploid endemic species *Triticum timopheevii* Zhuk (possessing genetic formula A^tA^tGG) is characterized by the unique gene pool controlling resistance to various wheat diseases. However, the use of this species in breeding processes with participation of the soft wheat (genetic formula AABBDD, 2n=42) is complicated by sterility and cytological instability of the hybrids obtained by crossing between these species. Lots of literatures contain versatile information on the transfer of a number of leaf rust resistance genes, including yellow rust and powdery mildew, from *T. timopheevii* to the soft wheat [5].

The present research was focused on introgressive lines derived from the complex hybridization of Kazakhstanskaya 3 line (*Triticum aestivum*, 2n=42) with *T. timopheevii* (2n=28) and subsequent double saturation breeding.

Materials and methods

Isogenic lines of variety Avocet, *T. timopheevii* sp., l-344 and l-345 introgressive lines, F_1 and F_2 hybrids were used.

The techniques used were: hybridological analysis was carried in inheritance generation F_2, and a statistical analysis of the deviation from the expected ratio of dominant and recessive phenotypes [6].

Plant resistance to the yellow rust was assessed by using Mains and Jackson's scale [7]. Resistance to yellow rust by the lines l-344 and l-345 was identified by using tester isogenic lines of Avocet- Yr 1/6, Yr 5/6, Yr 8/6, Yr 10/6, Yr 12, Yr 15, Yr Sp16 and Yr 17. F_1 hybrids were obtained by crossing the lines l-344 and l-345 with the carriers of effective Yr genes in the south-east of Kazakhstan- Yr5, Yr6, Yr7 8/6, Yr 10/6, Yr11, Yr 12, Yr 13, Yr 14, Yr 15, Yr 16, Yr 17 and Yr 24.

Results and discussion

Genetic analysis of resistance inheritance to wheat yellow rust, carried out by using the conventional hybridological analysis and gene allelism testing of the highly effective genes of Avocet allowed us to identify alleles introgressive and tester lines of wheat [8].

According to data of Zhang (2010) and Chun-Yan (2011) genetic analysis was conducted for resistance to yellow rust [9, 10]. The analysis of hybrids F_1, obtained by crossing introgression lines l-344 and l-345 with 12 varieties Avocet tester lines showed dominant character of inheritance for the resistance trait investigated in mature plants (Table 1).

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Table 1 – Inheritance of yellow rust resistance in F_1 hybrids obtained by the crossing of introgressive l-344 and l-345 lines with 12 isogenic lines based on cv. Avocet S.

Hybrid combination	Number of plants under study	Ratio of resistant and susceptible plants	
		R	S
Yr: 5 –8; 10 – 17, 24, Avocet R (YrA), Avocet S, Morocco, St x l-344	260	260	-
Yr: 5 –8; 10 – 17, Avocet R (YrA), Avocet S, Morocco, St.x l-345	250	250	-
Note: R-resistance; S-susceptibility			

The data on the population analysis of F_2 hybrids received from crossings of l-344 and l-345 lines with the lines carrying effective Yr genes showed all the hybrids splitting into resistant and susceptible plant populations corresponding to digenic and monogenic types of inheritance, with the exception of l-344 x Yr 5 and l-345 x Yr 10 hybrid populations (Tables 2 and 3).

According to literature data of Chen (1996) and Shimelis (2011) in F_2 progeny analysis shown that the ratio of resistant and susceptible plants corresponded to digenic and monogenic types of inheritance [11, 12].

Table 2 – F2 generation splitting by yellow rust resistance in crossing of l-344 line with isogenic lines of cv. Avocet S.

Crossing combination	Number of F_2 plant	Ratio of resistant and susceptible plants		c^2
		Actual value	Theoretical value	
Yr 5 x l -344	178	178	0	
Yr 6 x l -344	146	116 : 30	3:1	1.54
Yr 7 x l -344	168	121 : 97	3:1	0.79
Yr 8 x l -344	136	106 : 30	3:1	0.08
Yr 9x l -344	121	116 : 5	15:1	0.93
Yr 10 x l -344	142	105 : 37	3:1	0.08
Yr 11 x l -344	166	103 : 63	9:7	2.18
Yr 12 x l -344	134	102 : 32	3:1	2.27
Yr 13 x l -344	133	130 : 3	15:1	0.57
Yr 14 x l -344	144	122 : 22	13:3	0.13
Yr 15 x l -344	122	94 : 28	3:1	027
Yr 24 x l -344	153	44	3:1	0,75
Yr 17x l -344	133	98 : 35	13:3	0
Avoc. R (YrA) x l-344	224	158 : 66	3:1	2.37
Morocco, St.x l-344	259	186 : 73	3:1	1.40

The data on splitting among F_2 hybrid progeny shows that yellow rust resistance genes in l-344 line are not allelic to all the tester genes, which are highly effective in South-East Kazakhstan, except for Yr 5. The real ratio of resistant and susceptible plants in other combinations corresponded to monogenic, complementary, polymeric and epistatic gene interactions.

Table 3 – F2 generation splitting by yellow rust resistance in crossing of l-345 line with isogenic lines of cv. Avocet S.

Crossing combination	Number of F_2 plant	Ratio of resistant and susceptible plants		c^2
		Actual value	Theoretical value	
Yr 5 x l -345	203	120 : 83	9:7	0.69
Yr 6 x l -345	147	102 : 45	3:1	2.13
Yr 7 x l -345	154	124 : 30	3:1	2.50
Yr 8 x l -345	149	125 : 24	13:3	0.01
Yr 9x l -345	197	146 : 51	3:1	0.08
Yr 10 x l -345	158	158	0	
Yr 11 x l -345	171	131 : 40	3:1	0.24
Yr 12 x l -345	166	120 : 46	3:1	0.65
Yr 13 x l -345	184	170 : 12	15:1	0.03
Yr 14 x l -345	143	101 : 42	3:1	1.45
Yr 15 x l -345	132	102 : 30	3:1	0.36
Yr 24 x l -345	162	139 : 23	13:3	2.20
Yr 17 x l -345	136	98 : 38	13:3	0.30
Avoc. R (YrA) x l-345	302	219 : 83	3:1	1.07
Morocco, St.x l-345	213	127 : 86	9:7	0.99

In the F_2 hybrid populations obtained by crossing the line 345 with 12 testing lines, splitting to resistant and susceptible plants was not observed in combination with tester gene- Yr 10. F_2 hybrid population, obtained by crossing l-345 line and Yr 10 tester line showed no splitting into resistant and susceptible plants. This may reflect the resistance gene allelism to yellow rust of the donor and the recipient. Implication of alternative Yr testers revealed true values of splitting into stable and susceptible plants in seven crossing combinations which corresponded to monogenic inheritance for a single gene with complementary or polymer interactions, and epistatic interactions for two genes.

Thus, genetic study of yellow rust resistance in wheat introgressive lines l-344 and l-345 and identification of the group of effective resistance genes they belong to revealed the donors of resistance to yellow rust.

Genetic analysis showed that the resistance genes to yellow rust in the lines 344 and 345 depict dominant and monogenic nature of inheritance.

Genes of resistance to yellow rust in line l-344 have highly efficient alleles in south-east Kazakhstan tester gene – Yr 5, and the l-345 gene – Yr 10.

Resistance to leaf and yellow rust in introgressive lines l-344 and l-345 could be applied in practical selection of a valuable source of material for breeding.

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