RESISTANCE TO BROWN LEAF RUST OF HYBRIDS BETWEEN WHEAT AND AMPHIPLOIDS WHEAT-*THINOPYRUM*

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Abstract. The resistance to a brown leaf rust in 56 chromosomal partial amphiploids (*Triticum aestivum* L. × *Thinopyrum ponticum* (Podp.) Z.-W. Liu and R.-C. Wang), PA 2 (*Triticum aestivum* L. × *Thinopyrum intermedium (Host) Barkworth and* D.R. Devey), H79/9-9 (*Triticum aestivum* L. × *Elymus* sp.), *Triticum aestivum* L. cvs. Albatross odesskiy, Fantaziya odesskaya, Zhatva Altaya and their hybrids, F_2-F_4 were studied at artificial infection in field infectious nursery in 2009, 2010 and 2011. The investigated varieties of wheat have shown a high susceptibility to pathogen. Amphiploids PA 1 and PA 2 also are susceptible to pathogen, but in a lesser degree, than the wheat. Good resistance was shown only by amphiploid H79/9-9, but its hybrid with wheat Albatross Odessa appeared is susceptible to pathogen. The hybrids with amphiploids PA 1 and PA 2 have shown a various degree of resistance to brown leaf rust. Hybrid Zhatva Altaya × PA 2 within three years stably showed 8 point resistance to disease. The reasons for different resistance of amphiploids and its hybrids with wheat are discussed.

Keywords: brown leaf rust, resistance, wide crosses, wheat-alien amphiploids, *Thinopyrum ponticum, Thinopyrum intermedium.*

INTRODUCTION

One of the most widespread and nocuous diseases of wheat is the brown leaf rust caused by basidial fungus *Puccinia recondita* Rob. ex Desm. f. sp. *tritici* Erikss. et Henn. The epiphitoties of wheat disease, caused populations of races of a brown rust, cause serious damage to agricultural production. At development of strong epiphitoty shortages of a grain yield can achieve 40-50 % [12, 24]. The creation of varieties with resistance against an infection is one of the most effective among various measures of struggle against diseases. The genes of resistance to brown leaf rust have been entered into wheat from nuclear genomes *Triticum thimopheevii* [5, 17, 32], *Triticum dicoccum, Triticum persicum* [31], *Triticum militinae* Zhuk. and *Aegilops speltoides* Tausch. [9], *Aegilops columnaris, Aegilops variabilis, Aegilops squarrosa* L. (=*Triticum tauschii* (Coss.) Schmalh.) [17], *Aegilops umbellulata* [8], *Aegilops geniculata* [7], rye [18], wheatgrasses *Agropyron glaucum* [17], *Agropyron elongatum* Host (=*Thinopyrum ponticum* Liu&Wang) [16, 14] *Agropyron intermedium* Host (=*Thinopyrum intermedium* (Host) Barkworth and D.R. Devey) [28] by wide crosses. The introgressions from amphidiploids AD (*Ae. speltoides* × *T. monococcum*) [15], AD (*T. militinae* × *Ae. tauschii*) were also successful [10].

However, as a result of outstripping co-evolution of fungus the rust overcomes introgressed resistance genes. So, in the Volga region and other regions widely cultivate the spring bread wheat varieties, which contain *Lr19*-translocation from *Agropyron elongatum* Host (*Thinopyrum ponticum* LiuWang = *Lophopyrum elongatum*). But after achievement of area under crop over 100 thousand hectares protective effect of *Lr19*-translocation has been overcome by virulent pathotypes of leaf rust (*Puccinia triticina* Eriksson = *Puccinia recondita* f. sp. *tritici*) [29]. Therefore still actual attempts to transfer the resistance to leaf rust in wheat.

Recently in phytopathologic practice DNA-markers are used more and more widely. There was information about successful use of STS-markers for detection of alien introgression into wheat and for identification of resistance genes to brown leaf rust [13, 22, 35]. Unfortunately, the appointed markers not always can be used for definition of presence of resistance genes to brown leaf rust. So, effective genes seedling resistance *Lr9*, *Lr19* and *Lr24* are not always closely linked to the markers developed for them [34]. Therefore the method of field estimation in infectious nursery at artificial infection remains a reliable method of a direct estimation of resistance to diseases.

The purpose of the submitted work is the field estimation of stability to a leaf rust of wheat hybrids with wheat-alien amphiploids and also their parental forms.

MATERIALS AND METHODS

For the investigation were used wheat-alien 56 chromosomal partial amphiploids PA 1 (*Triticum aestivum* L. × *Thinopyrum ponticum* (Podp.) Z.-W. Liu & R.-C. Wang), PA 2 (*Triticum aestivum* L. × *Thinopyrum intermedium (Host) Barkworth &* D.R. Devey), H79/9-9 (*Triticum aestivum* L. × *Elymus* sp.), *Triticum aestivum* L. cvs. Albatross odesskiy, Fantaziya odesskaya, Zhatva Altaya and their hybrids, F_2-F_4 (Table 1).

The resistance of investigated forms has been studied at artificial infection in field infectious nursery in 2009, 2010 and 2011. For infection was used a population of races of a brown leaf rust (*Puccinia recondita* Rob. ex. Desm. f. sp. *tritici* Erikss. et Henn.), which meets in a southwest of Ukraine. In a population physiological races 77 (the most aggressive race) and 144 have prevailed. Races were designated on the qualifier by definition of races [19]. The ratio of races has varied on years. As the store of infection were used *Triticum aestivum* L. cvs. Odesskaya 26, Odesskaya polukarlikovaya and *Triticum compactum* Host. The level of defeat of these varieties achieved 100 % (corresponds to 1-2 points of a used scale). A degree of resistance estimated on a nine-mark scale according to a technique of an estimation of wheat resistance to diseases [1]. Thus took into account a single estimation at the maximal development of disease. Points 9-6 has characterized a different degree of resistance, points 5-1 – a different degree of susceptibility. They corresponded to the following quantity of the struck plants in percentage: 1 – 100%, 2 – 90%, 3 – 65%, 4 – 40%, 5 – 25%, 6 – 15%, 7 – 10%, 8 – 5%, 9 – 0% [2]. Statistical processing has carried out by the method of the one-factorial analysis of variance [25] after preliminary transformation of percentage estimation under the formula: $\varphi = 2\arcsin\sqrt{p}$

As a factor was considered nuclear genome. The data of each year served as a repetition.

RESULTS

The results of studying of hybrids and their parental forms resistance to activator of brown leaf rust are shown in the in Table 1. The investigated varieties of wheat have shown a high degree of resistance to pathogen. The amphiploids PA 1 and PA 2, contrary to expectations, also appeared to be sensitive to pathogen, though and to a lesser degree, than wheat. Good resistance has shown only amphiploid H79/9-9. However, its hybrid with wheat Albatross odesskiy appeared to be as susceptible to pathogen, as the investigated varieties of wheat. Completely other picture was observed concerning hybrids with amphiploids PA 1 and PA 2. They have shown a various degree of resistance to brown leaf rust.

The results of the variance analysis of resistance to brown leaf rust of hybrids and their parental forms are shown in Table 2.

Have been revealed significant (p≤0.01) differences on resistance of the investigated forms to brown leaf rust. Thus, hybrids PA 1 × Zhatva Altaya, PA 1 × Fantaziya odesskaya, Fantaziya odesskaya × PA 1, Zhatva Altaya × PA 2 and Fantaziya odesskaya × PA 2 significantly (p≤0.01) surpassed the wheaten parent on resistance to pathogen. Differences between reciprocal hybrids on resistance to disease were insignificant. Also, hybrids have shown better resistance to brown leaf rust, than amphiploids PA 1 and PA 2. However it was not possible to prove the significance of these differences.

The amphiploid H79/9-9 significantly (p≤0.01) surpassed on resistance to rust and wheat the Albatross odesskiy, and the hybrid between them.

DISCUSSION

The wheat Albatross odesskiy and Fantaziya odesskaya have shown a high susceptibility to brown leaf rust and during the previous period – 1999-2005 [33], despite of change of dominating races, which happened in 1997-1998 and 2003-2007 in the south of Ukraine [3, 4]. At the same time, in conditions of forest-steppe in northeast of Ukraine a variety the Albatross Odessa have shown resistance (6-9 ball resistance to this disease) [21].

The wheat-alien amphiploids and synthetic forms are usually positioned as sources of resistance to adverse biotic and abiotic factors of environment [11]. It concerns also to wheat-wheatgrass amphiploids to the full. So, 56-chromosomal incomplete amphiploid BE-1 (wheat-*Thinopyrum ponticum*) has 40 chromosomes from wheat and 16 chromosomes from a wheatgrass. It possesses resistance to leaf rust (*Puccinia recondita* f. sp. *tritici*) and powdery mildew (*Blumeria graminis* f. sp. *tritici*) [26]. The 56-chromosomal incomplete am phiploid TAI8335 (wheat-*Thinopyrum intermedium*) has one composite genome of the wheatgrass, con-

Table 1. The resistance to brown leaf rust of parental forms and introgressive hybrids of wheat (in points).

Variety, amphiploid, hybrid	2009	2010	2011	On the average for 3 years
Albatross odesskiy	2	4	5	3.7
Fantaziya odesskaya	2	4	4	3.3
Zhatva Altaya	2	4	4	3.3
PA 1	6	4	4	4.7
PA 2	4	4	5	4.3
H79/9-9	8	7	7	7.3
Zhatva Altaya × PA 1	4	8	4	5.3
Zhatva Altaya × PA 2	8	8	8	8.0
PA 1 × Zhatva Altaya	8	8	5	7.0
PA 1 × Fantaziya odesskaya	9	7	8	8.0
Fantaziya odesskaya × PA 1	9	5	6	6.7
Fantaziya odesskaya × PA 2	9	5	5	6.3
H79/9-9 × Albatross odesskiy	3	4	4	3.7

Table 2. The variance analysis of resistance to brown leaf rust in parental forms and introgressive hybrids of wheat.

Source of a variation	SS	df	mS	F_{fact}	F_{table} (p=0.01)
Total	15.09	38	–	–	–
Factor A (nuclear genome)	9.40	12	0.78	3.55**	2.96
Random deviations	5.69	26	0.22	–	–

** – difference significant at p≤0.01

sisting of one pair S-, three pairs J^s- and one pair J-genome chromosomes. This form was highly resistant to the leaf rust, the stem rust, stripe rust and powdery mildew. This makes from it the new source of transferring genes of complex resistance to fungi pathogen in wheat [6].

In our research amphiploid H79/9-9 has only shown a high degree of resistance to brown leaf rust, amphiploids PA 1 and PA 2 were susceptible to this disease. Probably, it's connected with differences in a chromosomal complement amphiploids and from a part – with their cytogenetic instability. So, at PA 1 56-chromosomal pollen mother cells were 77.6±2.8 %, the rest – hypoaneuploid (52-55 chromosomes, 20.3±2.7 %) and hyperaneuploid (59 chromosomes, 2,0±0,9 %) at cells. Rather frequently met multivalents (up to pentavalent). The meiotic instability also reflects meiotic index (% normal tetrads). It was 43.0±1.7 %. Among abnormal products of the meiosis prevailed tetrads with micronuclei [27].

The hybrids with amphiploids PA 1 and PA 2 have shown mainly a high degree of resistance to brown leaf rust. The hybrid Zhatva Altaya × PA 2 stood out in this respect. Within three years it stably showed 8 point resistance to disease. Other hybrids have shown variability to given attribute: from 9 point resistance down to a moderate susceptibility (5 points). Most likely, it is connected with cytological instability of hybrids, because at crossing hexaploids with octoploids cytological instable 49-chromosomal plants are formed. Which in a number of generations come back to a level ploidy of one of its parents, as a rule of hexaploid. It is also impossible to exclude influences of mendelian segregation in a hybrids.

As to influence of environmental conditions, of course, it is impossible to exclude it completely. However, in special experiments it is shown, that introgressive hybrids with resistance to diseases (to powdery mildew, brown rust, septorioses, helmintosporioses) have an average level of interaction of genetic factors with conditions of environment [20].

Attempt to transfer resistance to brown leaf rust from the resistance amphiploid H79/9-9 to wheat was unsuccessful. The better disease resistance of hybrids with amphiploids PA 1 and PA 2, in comparison with both parents, probably, is explained by interaction of genes. It is necessary to find out, whether has a place interaction concrete non allelic genes, as it has been established for gene *Lr27*, which determines resistance to leaf rust only complementarity with gene *Lr31* [30], or it is connected to change of genetic background and/or cytogenetic constitutions. By the formal attribute such resistance of hybrids in comparison with susceptible parents gets under definition of transgression. But, unfortunately, the theory of transgression of attributes and properties isn't developed yet; there are no uniform and adequate explanations of this genetic phenomenon [23]. Therefore we can't assert that mechanisms of transgression lay in a basis of resistance of hybrids with amphiploids PA 1 and PA 2. However, the received hybrids present practical interest and need the further phytopathologic, genetic and cytogenetic studying.

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