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Dominance and recessiveness of parameters of Aluminum-resistance of barley F_2 hybrids at different concentrations of stress factor

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Till now there is no uniform opinion in the scientific literature about number and type of action of genes coding barley aluminum resistance. For example, Rigin, Yakovleva (2001) considers, that it is controlled by two oligogenes, as a minimum, with possible action of genes with weaker effect. Other authors assume the control of the parameter by one dominant gene *Pht* [Stolen, Andersen, 1978], or gene *Alp* [Reid, 1971], both located on chromosome 4 [Minella, Sorrells, 1997].

Gourley et al [1990] concluded, that type of action of genes coding aluminum resistance in sorghum (additive, partially or completely dominant), depends not only on a researched genotype, but also on used Al concentration. Aniol [1995, 1996] has established, that when the concentration of aluminum in test solution is low (30-40 µM), cereal cultures (wheat, rye) use mechanisms that block accumulation of aluminum in roots (for example, chelation of aluminum at the expense of exudation of organic acids by root system), at higher concentration of aluminum in root growth environment (200-300 µM) the basic role is played by other physiological mechanisms of Al-resistance. Thus the author remarks [Aniol, 1997] that the aluminum resistance of wheat plants at a concentration of 296 µM is controlled by 2 genes and at a concentration of 592 µM aluminum resistance is controlled by three genes. He wrote, that genes located in D-genome of wheat, are expressed only at high Al concentration, and genes located on chromosome 5A are expressed at all studied concentrations.

The aim of our research was to determine the influence of Al concentration on a direction and character of dominance of parameters of roots growth of barley F_2 hybrid seedlings.

Material and Methods

The direct and reciprocal F_2 hybrids of four selection numbers of barley (№№ 565-98, 889-93, 999-93 and 1030-93), bred in North-East Agricultural Research Institute (Kirov, Russia) were taken for the analysis. By results of the preliminary laboratory analyses the parental forms of these hybrids differed significantly on a level of Al-resistance that corresponded to the research aim. A level of Al-resistance (relative root length - RRL) was estimated under conditions of rolled culture on five-day barley seedlings according to the technique described earlier [Lisitsyn, 2000] by division of value of root length of each individual seedling in test treatment variant (0.5 and 1.0 mM of aluminum as sulphate salt, pH 4.3) on value of average root length of control variant (without the stress factor, pH 6.0). Each sample volume consists of 99-105 seedlings in each treatment variant.

Character of dominance for parameters of root growth of F_2 hybrid plants was estimated by equation [Petr, Frey, 1966]:

$$d = \frac{F_2 - MP}{HP - MP}$$

,
where d = degree of dominance; F_2, HP, MP = means of F_2 hybrids, resistant parent value, and mid parent value, respectively.

Results and Discussion

Expression of Al-resistance genes appreciably depend on a concentration of aluminum in test solution and with its increase the resistance of all hybrids was reduced without exception (table 1).

Table 1. Parameters of root growth of barley F_2 hybrids under laboratory condition

Hybrid	Root length, mm			RRL, %	
	0 mM Al	0.5 mM Al	1.0 mM Al	0.5 mM	1.0 mM
565-98 x 889-93	109.2±1.5	71.2±1.2	56.3±1.0	65.2±0.6	51.6±0.5
889-93 x 565-93	103.0±1.1	84.7±1.3	71.3±1.2	82.3±0.7	69.2±0.7
565-98 x 999-93	113.6±1.6	71.8±1.8	48.3±1.2	63.2±0.9	42.6±0.6
999-93 x 565-98	103.3±2.2	65.8±0.9	55.3±1.2	63.7±0.5	53.5±0.7
565-98 x 1030-93	112.7±1.1	74.2±1.1	57.0±1.3	65.8±0.6	50.6±0.7
1030-93 x 565-98	110.8±1.4	79.3±1.3	65.2±1.0	71.6±0.7	58.8±0.5
889-93 x 999-93	107.7±2.2	76.0±1.7	61.0±1.5	70.5±0.7	56.6±0.8
999-93 x 889-93	106.9±1.1	70.7±1.5	58.2±0.8	66.1±0.8	54.5±0.4
889-93 x 1030-93	107.6±1.4	75.0±2.0	64.5±1.5	69.7±1.1	59.9±0.8
1030-93 x 889-93	102.1±1.6	79.0±1.0	62.9±0.8	77.4±0.6	61.6±0.5
999-93 x 1030-93	104.9±1.6	75.6±1.6	52.2±1.7	72.0±0.9	49.8±0.9
1030-93 x 999-93	111.2±1.2	77.4±1.0	59.6±1.2	69.5±0.5	53.6±0.6

As it is visible from data, submitted in table 2, depending on the cross and aluminum concentration used, for some hybrids the large value of root length was dominated, for others hybrids – the smaller value, but for the third part of hybrids dominance of root length was absent practically. It is possible to note the same character of dominance for RRL parameter. The similar phenomenon was earlier marked in the literature for other cereals. So, [Camargo, 1981, 1984] pointed out, that Al-resistance of wheat F_2 population was coded by dominant genes at concentration of aluminum 3 mg/l, but became recessive at increase of concentration of the stressful factor up to 10 mg/l. Similar results were described in the researches with wheat [Bona et al., 1994].

Table 2. Influence of direction of crossing on character of dominance of parameters of root growth of barley F_2 hybrids

Hybrid	Degree of dominance of a parameter				
	Root length			RRL	
	0 mM Al	0.5 mM Al	1.0 mM Al	0.5 mM	1.0 mM
565-98 x 889-93	0.33	-0.78	-1.94	-1.21	-5.35
889-93 x 565-93	-0.94	0.34	1.26	0.99	5.00
565-98 x 999-93	1.19	-1.42	-1.51	-4.65	-3.13
999-93 x 565-98	-0.44	-2.12	-0.70	-4.50	-0.85
565-98 x 1030-93	-0.81	-0.45	-0.51	-0.37	-0.40
1030-93 x 565-98	-2.00	-0.05	0.44	0.11	0.13
889-93 x 999-93	4.33	1.18	1.10	-0.16	0.23
999-93 x 889-93	3.80	-0.38	0.40	-1.16	-0.47
889-93 x 1030-93	-0.25	10.14	1.98	1.67	1.15
1030-93 x 889-93	-1.11	15.96	1.58	3.47	1.40
999-93 x 1030-93	-0.35	1.05	-4.00	0.59	0.17
1030-93 x 999-93	0.44	1.49	7.00	0.30	1.22

As it is follows from data, submitted in table 2, depending on a concrete combination of crossing domination of root length under control conditions, under both Al treatments and of RRL parameter can have positive or negative meanings, changing from negative super-domination till positive super-domination. Character and direction of domination can coincide for parameters of roots length under control conditions and under aluminum treatment, but sometimes can have an opposite direction.

Directions of crossing caused opposite character of dominance of researched parameters of Al-resistance for hybrids 565-98 x 889-93 and 889-93 x 565-98. This tendency is some less expressed at hybrids received from crossing of breeding numbers 565-98 and 1030-93. At the same time direct and reciprocal hybrids between breeding number 565-98 and breeding number 999-93 for main part of researched parameters have shown only different degree of dominance, but not its different direction.

Direct and reciprocal hybrids between selection numbers 889-93 and 1030-93 had least differences on a direction and character of dominance.

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