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THE TOLERANCE OF CHOSEN SPRING WHEAT TO THE STRESS EFFECT OF ALUMINIUM IONS

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A b s t r a c t. The tolerance of spring wheat seedlings to the toxic effect of aluminium ions was analysed in the present paper. The laboratory test was carried out in the aquaculture applying various concentrations of aluminium ions in the medium (3, 6 and 9 mg/kg). Five F_3 hybrid combinations of spring wheat as well as initial forms were examined. The hybrids Inia 66/16 x Henika and Inia 66/16 x Kadett marked out with high tolerance to toxic aluminium.

K e y w o r d s: spring wheat, aluminium ion, toxic effect, seedling tolerance

INTRODUCTION

The toxic effect of aluminium ions on the seedlings of cultivated plants in acidified soils is considered, at present, the basic cause of the decrease in crop yields [4,8]. The effect of stress influence of aluminium is the shortening of the root system and the inhibition of the above-ground plant development. Wheat is the most sensitive cereal crop after barley to the toxic effect of aluminium ions.

MATERIALS AND METHODS

The tolerance of the seedlings of chosen spring wheat genotypes on toxic action of aluminium ions in aquaculture and the results of biometrical measurements were analysed. Five cross combinations F_3 and their initial forms (Inia 66/16 ♀ ; Alfa, Eta, Henika, Jara, Kadett ♂) were examined. A field experiment in 1991 was started on loess soil with pH=5.8.

The aim of the present study was to determine the variability of basic utility properties of plants and the levels the seedlings tolerance to toxic aluminium ions in the laboratory conditions. The laboratory test in aquaculture was carried out with the method worked out by Aniol [1]. The seeds underwent initial sprouting germination and were placed in the medium of definite composition (pH=4, at 25 °C). Four days old seedlings were moved for 24 h to the identical medium with the addition of aluminium at a rate of 3, 6 and 9 mg/kg. Then the seedlings were transfered for 24 h to the medium without aluminium. After that time, the roots of seedlings were being dyed for 15 min in 0.1 % solution of Eriochrom cyanine R. It forms with aluminium a compound of bron-purple colour which is neutral for the plants. The tolerance of 100 seedlings was evaluated for each form tested. The basis for the evaluation of tolerance to a given concentration of aluminium was the root regrowth beyond the aluminium absorption zone. Thirty plants from each parent form and 60 hybrids underwent the biometric measurements of 10 main features. Then, arithmetic means (x), variability coefficients (W), and the lowest significant differences (LSD) were calculated.

RESULTS AND DISCUSSION

Table 1 presents the main characteristics (x, W, LSD) of the tested parent lines and their hybrids. Among 10 tested features, statistically significant differences between the initial lines and their hybrids were noted for their majority. Among parent forms - the mother form Inia 66/16 had the highest number and mass of grains from the main spike as well as grain mass from the plant and the weight of 1 000 grains. In the conditions of field experiment it had, however, too flabby, susceptible to lodging straw. The most favourable arrangement of the tested features - elements of the crop structure - occurred in the hybrids Inia 66/16 x Alfa and Inia 66/16 x Henika. The variability coefficients and the mean values of the features tested seem to indicate great potential possibilities of selection among these combinations of lines with modern ideotype.

The generally known high interdependence between the results of laboratory testes and those of field experiments on acid soils justifies the necessity of their applying during the selection of plants tolerant to toxic aluminium ions. The results of laboratory tests in aquaculture are presented in Table 2. The variety originating from Brazil - Inia 66/16, having a very high tolerance to the effect of aluminium ions, was used as a model. It confirmed its resistance to all the aluminium concentrations added to the medium. All the remaining parent varieties appeared to be very sensitive. Only at Henika and Kadett varieties

Table 1. Means ($\bar{x}$) and variability coefficient (W) for investigated features or spring wheat

Variety or cross combination		Length of main stem (cm)	Total number of stems	Number of productive stems	Data concerning main stem					Weight of kernels from the plant (g)	1000 kernel weight (g)
					Length of rachilla (cm)	Number of spikelets in the spike	Spike density (g/cm^3)	Number of kernels from the spike	Weight of kernels from the spike (g)		
Inia 66/16	$\bar{x}$	84.1	8.0	7.8	9.0	19.4	20.5	56.7	2.18	8.2	38.6
	W	6.6	28.8	29.8	8.8	6.6	8.9	17.5	17.9	32.7	8.3
Alfa	$\bar{x}$	78.6	7.2	6.8	10.7	20.0	17.9	44.4	1.58	4.9	35.6
	W	4.2	27.1	31.2	6.1	8.8	10.0	9.2	18.2	24.5	15.2
Eta	$\bar{x}$	90.6	6.0	5.6	9.4	21.8	22.2	45.0	1.70	5.3	37.8
	W	3.7	26.6	31.1	6.7	5.2	6.6	8.4	11.6	20.7	8.1
Henika	$\bar{x}$	83.1	7.5	5.9	10.7	18.4	16.3	49.4	1.74	4.3	35.0
	W	9.7	30.4	24.9	7.6	6.8	6.9	25.3	31.2	53.1	15.1
Jara	$\bar{x}$	93.7	5.0	5.0	9.8	20.3	19.7	41.4	1.37	3.0	32.6
	W	4.5	23.6	23.3	5.2	2.9	5.1	29.6	34.4	50.2	14.2
Kadett	$\bar{x}$	92.0	6.9	6.6	8.1	18.2	21.4	41.0	1.44	4.9	34.9
	W	4.8	22.0	21.1	12.0	9.2	11.9	25.5	32.5	46.9	19.8
Inia 66/16 x Alfa	$\bar{x}$	83.3	7.6	7.4	9.4	18.7	18.9	49.2	1.99	8.6	40.4
	W	10.9	38.6	40.1	11.7	9.3	12.3	19.4	24.6	54.9	13.8
Inia 66/16 x Eta	$\bar{x}$	87.8	6.8	6.6	8.9	19.5	20.9	55.0	1.99	6.9	36.6
	W	9.4	32.1	32.9	12.1	7.4	11.5	20.2	31.0	50.0	33.6
Inia 66/16 x Henika	$\bar{x}$	90.9	5.9	5.4	9.5	18.0	18.0	48.1	1.71	4.0	35.8
	W	12.3	41.8	38.1	10.0	9.8	9.9	20.3	36.9	61.0	39.3
Inia 66/16 x Jara	$\bar{x}$	89.4	6.1	5.2	8.8	18.2	19.7	48.5	1.64	3.7	34.0
	W	8.9	33.4	31.5	10.1	7.4	9.2	16.7	27.6	52.8	22.6
Inia 66/16 x Kadett	$\bar{x}$	94.0	6.5	5.9	8.8	18.5	20.0	47.1	1.63	4.0	33.2
	W	14.0	46.3	46.0	14.4	11.6	9.9	31.7	42.2	83.7	21.5
$LSD_{0.05}$		7.72	2.07	1.91	0.89	1.50	1.80	6.54	0.45	2.54	8.36

Table 2. Aluminium tolerance of parent lines and hybrids expressed as % root regrowth

Variety or cross combination	Concentration of Al ions in the medium (mg/kg)		
	3	6	9
Inia 66/16	100.0	100.0	84.5
Alfa	0.0	0.0	0.0
Eta	0.0	0.0	0.0
Henika	2.5	0.0	0.0
Jara	0.0	0.0	0.0
Kadett	1.5	0.0	0.0
Inia 66/16 x Alfa	71.3	45.1	19.1
Inia 66/16 x Eta	90.3	76.1	30.0
Inia 66/16 x Henika	78.0	74.3	41.7
Inia 66/16 x Jara	82.2	51.1	18.4
Inia 66/16 x Kadett	92.0	78.1	43.8

2.5 and 1.5 % of seedlings, respectively, with the roots regrowing at the lowest aluminium concentrations applied was noted. It indicates the possibility of the selection of isogenic lines of these varieties with a certain tolerance to this stress factor. However, all the hybrids had an interesting tolerance, from the breeding point of view. A considerably high percentage of seedlings with roots regrowing (i.e., tolerant) at 9 mg/kg of aluminium, oscillating from 18.4 to 43.8 %, enables the breeder the choice of plants with favourable ideotype. At the maximal concentration of aluminium ions in the medium, the highest percentage of tolerant seedlings was found in the combinations of Inia 66/16 x Kadett and Inia 66/16 x Henika. In all the hybrids the decrease in the number of tolerant seedlings was noted together with the increase in the aluminium ion concentrations in the medium. A considerable amount of hybrid seedlings with regrowing roots indicates the real possibilities for selecting among them the lines tolerant to toxic aluminium in acidified soils. The obtained results confirmed the author's earlier research [5-7], concerning Brazilian varieties and those regionalized in Poland, as well as the earlier generations of these and other hybrids in the respect of their response to toxic aluminium. Also the research carried out by Aniol [1-3], concerning the transfer of genes' tolerance, to aluminium ions, from Brazilian varieties to those regionalized in Poland clearly confirms the sense and purpose fulness of these studies.

CONCLUSIONS

1. The results of the laboratory tests of seedlings confirmed the very high tolerance of the model Brazilian variety - Inia 66/16 as well as the sensitivity of the varieties regionalized in Poland.

2. From among the hybrids tested, the combination Inia 66/16 x Henika marked out with the high tolerance to toxic aluminium ions as well as with the most favourable ideotype.

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TOLERANCYJNOŚĆ WYBRANYCH GENOTYPÓW PSZENICY JAREJ NA STRESOWE DZIAŁANIE JONÓW GLINU

Toksyczność glinu uważana jest obecnie za główny czynnik limitujący produktywność roślin na zakwaszonych glebach. W pracy analizowano tolerancyjność siewek różnych genotypów pszenicy jarej na toksyczne jony glinu w kulturze wodnej oraz wyniki pomiarów biometrycznych roślin. Testowano 5 kombinacji krzyżówkowych F_4 oraz ich formy wyjściowe (♀ - Inia 66/16, ♂ - Alfa,

Eta, Henika, Jara, Kadett).

W obrębie każdej formy rodzicielskiej poddano pomiarom biometrycznym po 30 roślin, natomiast kombinacji mieszańcowej 60 pojedynków. Dla wszystkich 10 badanych cech obliczono współczynniki zmienności, średnie arytmetyczne oraz istotność różnic.

Spośród komponentów rodzicielskich najwyższą tolerancyjność na jony glinu wykazał światowy wzorzec odporności na ten czynnik - odmiana brazylijska - Inia 66/16. Pozostałe odmiany potwierdziły swoją wrażliwość na działanie glinu. Nowoczesnym ideotypem roślin oraz pożądaną tolerancyjnością na toksyczne działanie jonów glinu wyróżnił się mieszaniec Inia 66/16 x Henika.

S ł o w a k l u c z o w e: pszenica jara, toksyczność jonów glinu.