TOLERANCE OF SOME WINTER WHEAT GENOTYPES TO ALUMINIUM ION TOXICITY

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ABSTRACT

In Romania, under conditions of acid soils, the cultivation of tolerant winter wheat genotypes to aluminium ion toxi-city, has become a necessity for the obtainment of economical yields. The tolerance of winter wheat to soil aluminium ion toxicity is a complex phenomenon which is determined by factors with different implications into the tolerance manifestation. There is a certain variability of Romanian and foreign germplasm as regards the tolerance to aluminium ion toxicity. From all tested cultivars, 28 genotypes had a favourable answer to aluminium ion toxicity, from which 10 winter wheat genotypes are tolerant, they being an important source of germplasm for this cultivar trait.

Key words: aluminium ion toxicity, germplasm, winter wheat genotype.

INTRODUCTION

In the area of acid soils of Albota, the main limitative factor of wheat yield is the presence of aluminium ions.

The high concentration of available aluminium ions, up to 100 ppm, over the phytotoxicity limit (50 ppm Al3+ – for wheat), strongly limits the wheat yielding potential by the root system braking (Foy et al., 1967), inhibition of DNA synthesis from root and of photosynthesis (Wallace and Anderson, 1984) and by the soil phosphorus binding into insoluble aluminium phosphates, making it unusable into metabolic processes of plants (Kiesselbach, 1949; Hume et al., 1984, quoted by Ittu and Saulescu, 1988). Aluminium largely affects the root growth (Wallace and Anderson, 1984) and less the foliar surface (Bunta, 1977). Fleming and Foy (1968) and Kauffman and Gardner (1978) showed that the aluminium behaves as an inhibitor of the root growth, having as effect a superficial root system, sensitive to drought and frost, with a reduced abi-lity of water and nutrients absorbtion. The root length decreases at the same time with the aluminium concentration increase, but stronger at untolerant cultivars (Ittu and Saulescu, 1988). The root length decrease is the most typical symptom of aluminium ion toxicity. The amendments application has limited value as practical solution for the acidity neutralisation which induces the aluminium ion excess (Aniol and Gustafson, 1984). The selection and breeding of genotypes tolerant to aluminium ion toxicity is a promising alternative for the aluminium ion toxicity solution – characteristics of acid soils.

At Pitesti-Albota A.R.D.S., under acid soil conditions with high concentration of aluminium ions, the Albota cultivar was released, with medium tolerance to this element but with high yielding ability and very well adapted to Albota conditions. This fact could lead to the obtainment of winter wheat genotypes with high tolerance to aluminium ion toxicity but, at the same time, with a stable and high genetic yielding potential, resisting to diseases and lodging, with breadmaking quality and which efficiently use the natural conditions. This matter will be possible only by the utilization of genitors which would combine all these traits and by selection under stress conditions (over 100 ppm Al^{3+}).

MATERIALS AND METHODS

The tested biological material consisted of 28 winter wheat genotypes, one triticale cultivar (Plai) and one rye cultivar (Gloria). The two species, tolerant to acidity and high concentrations of aluminium ions were tested alongside of wheat genotypes, in order to better evaluate their tolerance degree. The research were performed under field, laboratory and glasshouse conditions. The experiments were performed in randomized blocks, in three repetitions and on two soil types:

– brown luvic soil, for testing both yielding and tilling ability, resistance to diseases and growth rhythm at low temperatures;

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– albic luvisoil, for testing both tolerance to aluminium ion toxicity and adaptability to acid soils.

The testing in Mitcherlich pots was performed under laboratory conditions on two soil types (Table 1) in two periods: 1st-10th April – period in which the growth of plants was tested ten days from the emergence in order to determine in what measure the root growth is affected by the aluminium ion pre-sence in high concentrations during the first days of life; 1st–30th April – in order to observe in what measure the root growth is embarrassed by the presence, in smaller or greater quantity, of some nutrients from soil. The method consists of plant growth (four plants/pot) in plastic glasses with 185 g soil. The growth conditions consisted of the moisture maintenance to 75% from the field capa-city, a temperature of 20 ± 2ºC and 13 hours of light/day. The experiment was carried out in there replications.

Table 1. Chemical features of soil (brown luvic and albic luvisoil) utilized in Mitcherlich pots

Soil	pH	Al^{3+} ppm	P ppm	N ppm
Brown luvic soil	4.90–5.00	49.00	23.07	13.30
Albic luvisoil	4.50–4.70	129.00	6.76	8.00

The method of experimentation in Mitcherlich pots on two soil types, of which one with aluminium ions excess, emphasized the genotypes reaction to the specific conditions of an acid soil and especially to the aluminium ion toxicity. On the basis of this method, the influence of aluminium ions on root growth could not be separated from the other harmful soil factors. In order to emphasize the phytotoxic effect of aluminium ions the material was tested on nutritive solutions with aluminium. A method elaborated by Bunta (1997) was used. This method consists of plants germination and growth on filter paper rolls at temperature of 20–22°C, 48 hours, after which the plants with embryonic roots are moved on growth solutions (distilled water + $AlCl_3$ x 6 H_2O). After ten days, the root length are measured. During this period, the temperature was of 20–22°C and 13 hours/day light. By this method, the relative growth of the genotype roots tested on nutritive solution with aluminium vs. root growth on solution without aluminium, was determined.

In order to establish the tolerance level to the aluminium ion toxicity of those genotypes, nutritive solutions with 0.4 and 8 ppm Al^{3+} concentrations, were utilized.

The experiment controls were the Albota cultivar for yielding ability and adaptability and Atlas 66 cultivar for tolerance to alumi-nium ion toxicity.

The estimation of winter wheat genotypes behaviour to the aluminium ion toxicity was made by the comparison of field determinations performed in the same locality and in the same year under conditions of acid soil with aluminium ion excess (albic luvisoil) as well as on brown luvic soil.

Data interpretation was made by variance analysis (Ceapoiu, 1968), simple correlations and regressions (Ceapoiu, 1968), and method of sensitivity index to stress (Fischer and Maurer, 1978).

The sensitivity index to stress was calculated by the formula:

$$S = (1 - ys/yn)/D$$
$$D = 1 - ysm/ynm$$

in which:

ys = genotype yield under stress conditions (aluminium ion toxicity);

yn = genotype yield under normal conditions;

D = stress density or intensity;

ysm = mean yield of all genotypes under stress conditions;

ynm = mean yield of all genotypes under normal conditions.

The sub-unitary values of sensitivity index show a better tolerance and the over-unitary values a greater sensitivity than the average of file.

RESULTS AND DISCUSSION

During 1989-1992, on albic luvisoil, the yield ranged between 29.4 q/ha at Atlas cultivar and 46.2 q/ha at A 74-86 line (Figure 1). The control, Albota cultivar, achieved an yield of 43.7 q/ha, superior to all tested cultivars. The A 36-85, A 2-88, A 74-86, A 8-88, A 3-89 and A 7-89 lines achieved superior but not significant yield gains vs. control. The Gloria and Plai cultivars achieved yields close to that of control (42.6 q/ha, 41.0 q/ha respectively).

On brown luvic soil, during the four years of experimentation, the yield ranged between 43.3 q/ha at Atlas cultivar and 79.4 q/ha at A 10-89 line. The Albota control achieved an yield of 75.9 q/ha. Yield gains vs. control were achieved by Trivale cultivar (2%), and lines A62-89 (4%), A 905-80 (4%), A 103-86 (4%), A 8-88 (2%), A 135-86 (2%). The greatest mean yields on these two soil types were achieved by the A 36-85, A 74-86, A 3-89, A135-86, A 62-89, A 7-89 lines, superior yields to Albota control and as compared with the other experimental cultivars. The Plai triticale cultivar achieved similar yields with those of the control and Gloria rye cultivar achieved significantly smaller yields, due to severe plants lodging. The Atlas 66 cultivar, although has a high tolerance to aluminium ion toxicity, proved to have a very low yield genetic potential with sensitivity to lodging.

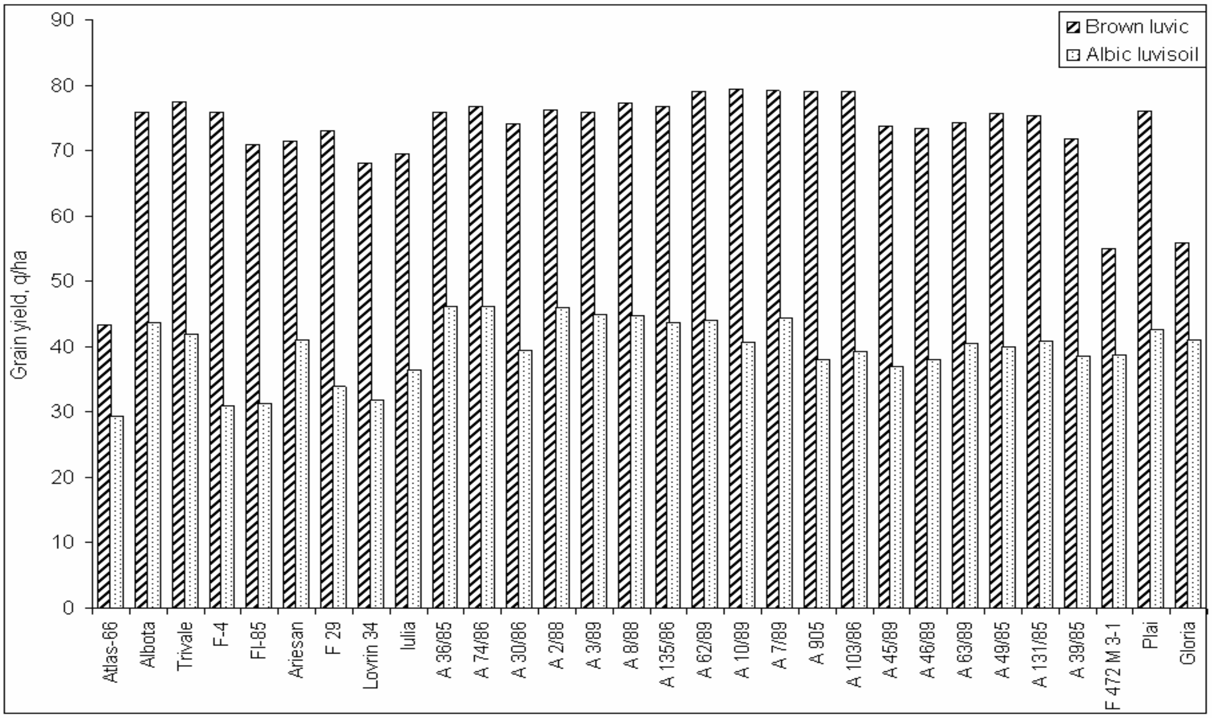

Figure 1 - Yield obtained by the genotypes cultivated on brown luvic soil and albic luvisoil (Albota, 1989-1992)

The comparative analysis of winter wheat genotypes both on acid soil with aluminium ion excess (albic luvisoil) and acid soil with small quantities of free aluminium ions (brown luvic soil), during 1989–1992, brings information about the phytotoxic effect of aluminium ions on the genotypes behaviour. The correlation between yield obtained on albic luvisoil and that obtained on brown luvic soil calculated for all experimental genotypes was positive and distinctly significant (Figure 2).

In the experiments with Mitcherlich pots, after ten days of testing, the following results were registered:

– on albic luvisoil, at the control Atlas 66, the root length was on an average, of 19.6 cm. At Fundulea 4, Flamura 85, Lovrin 34, A 74-86, A 8-88, A 46-89 and A 131-85 genotypes, significantly negative differences of root length as compared with Atlas 66 control, were re-gistered. The Albota line A 103-86 registered significantly positive gains of root length (Figure 3).

– on brown luvic soil, at the majority of genotypes, the root growth was more intense than on albic luvisoil, so that, a lot of genotypes significantly exceeded the Atlas 66 cultivar root length. Among these, the cultivars Trivale, Fundulea 4, Flamura 85, Iulia, A 10-89, A 103-86 and A 63-89 could be distinguished (Figure 3).

The calculation of the tolerance index to aluminium ion toxicity, showed that 12 wheat genotypes registered values close to those of the control, suggesting that these genotypes have a good

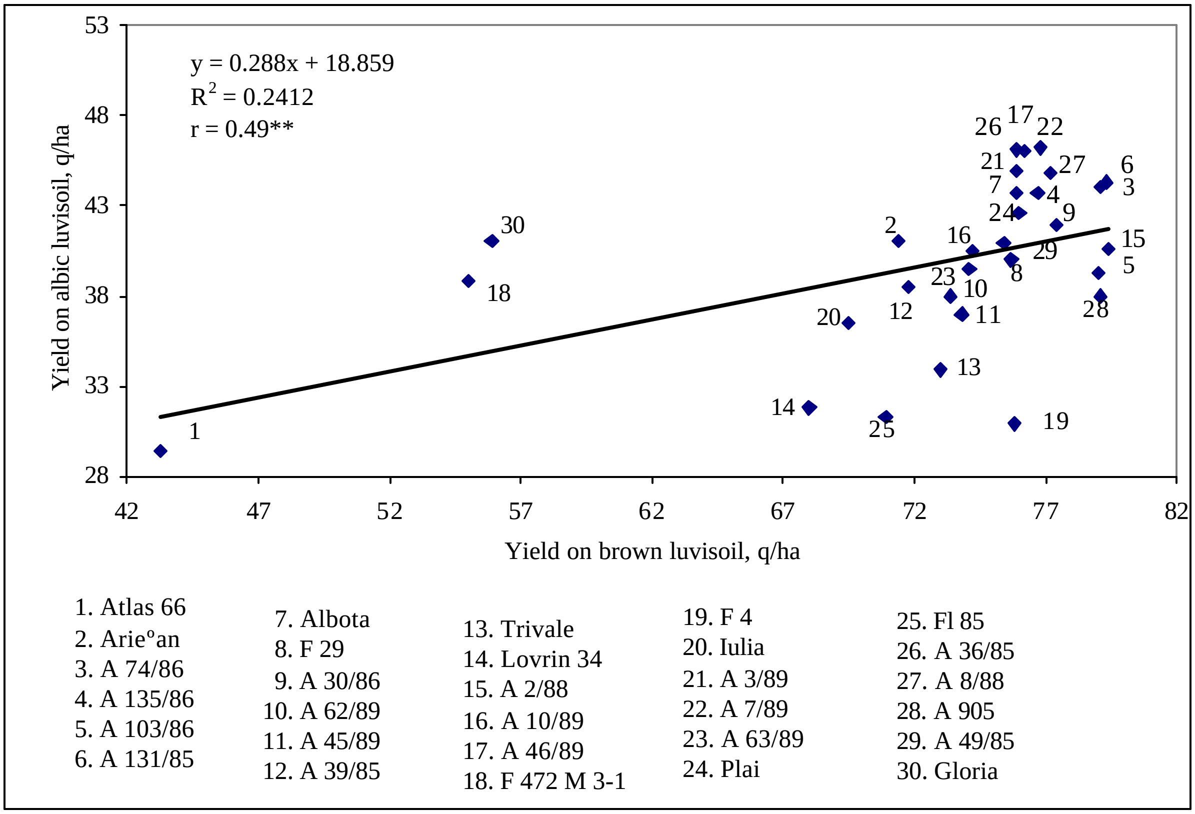

Figure 2. Correlation between yield of genotypes cultivated on albic luvisoil and brown luvic soil (Albota, 1989–1992)

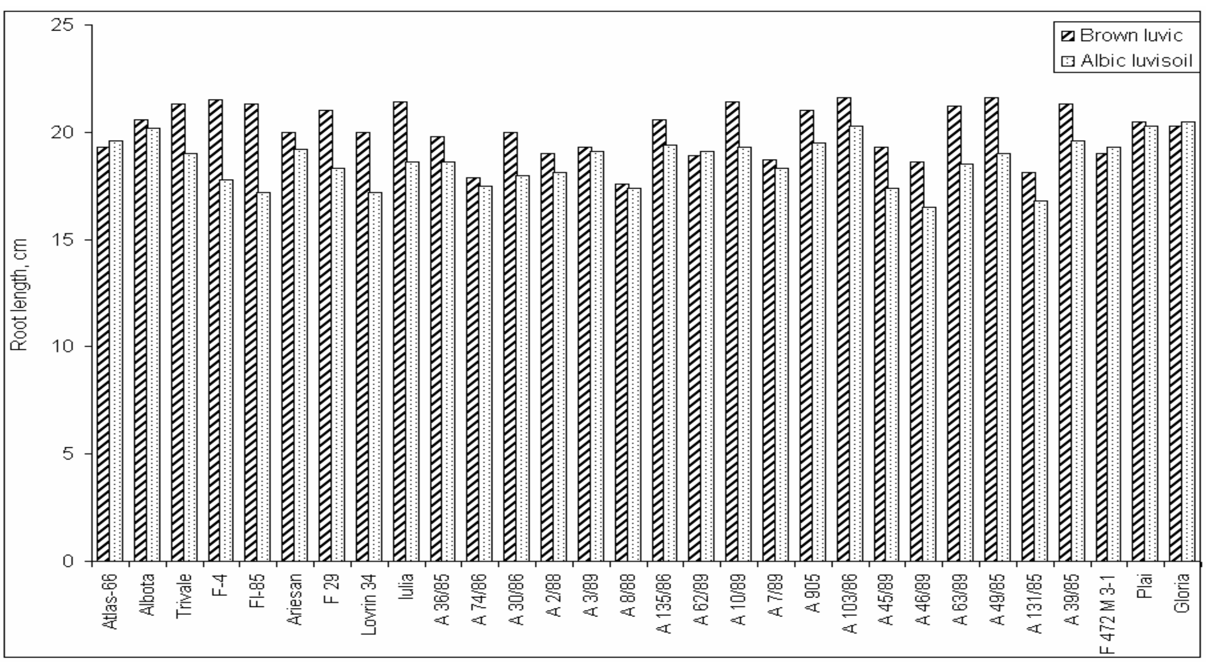

Figure 3. Length of root genotypes cultivated on albic luvisoil and brown luvic soil (Mitcherlich pots, ten days)

tolerance to aluminium ion toxicity or a better

Table 2 . Root length, stress and tolerance indices at winter wheat lines and cultivars obtained in Mitcherlich pots with brown luvic soil and albic luvisoil

Variants	Root length (cm) at 10 days				Root length (cm) at 30 days			
	AL	BL	Stress index to Al^{3+}	Tolerance index	AL	BL	Stress index to Al^{3+}	Tolerance index
Atlas 66	19.6	19.3	0.14	1.01	24.8	24.7	0.00	1.00
Albota	20.2	20.6	0.28	0.98	29.5	29.3	0.00	1.00
Trivale	19.0	21.3	1.57	0.89	28.0	30.0	0.87	0.93
Fundulea 4	17.8	21.5	2.57	0.82	22.0	28.5	2.87	0.77
Flamura 85	17.2	21.3	2.71	0.82	23.0	28.0	2.25	0.82
Arieºan	19.2	20.0	0.57	0.98	26.8	27.4	0.25	0.98
Fundulea 29	18.3	21.0	1.85	0.74	21.4	29.0	3.25	0.74
Lovrin 34	17.2	20.0	2.00	0.83	20.1	24.0	2.12	0.83
Iulia	18.6	21.4	1.86	0.89	26.3	29.4	1.38	0.89
A 36/85	18.6	19.8	0.86	0.98	28.3	29.0	0.25	0.98
A 74/86	17.5	17.9	0.28	0.92	26.6	28.8	1.00	0.92
A 30/86	18.0	20.0	1.43	0.91	24.3	26.8	1.12	0.91
A 2/88	18.1	19.0	0.71	0.94	27.5	29.3	0.75	0.94
A 3/89	19.1	19.3	0.14	0.98	27.4	27.8	0.25	0.98
A 8/88	17.4	17.6	0.14	1.00	27.1	27.0	0.00	1.00
A 135/86	19.4	20.6	0.86	0.95	27.4	28.9	0.62	0.95
A 62/89	19.1	18.9	0.14	0.92	25.6	27.8	1.00	0.92
A 10/89	19.3	21.4	1.43	0.92	27.0	29.3	1.00	0.92
A 7/89	18.3	18.7	0.28	0.83	25.0	30.0	2.12	0.83
A 905/80	19.5	21.0	1.14	0.91	23.0	25.2	1.12	0.91
A 103/86	20.3	21.6	1.00	0.98	26.0	28.3	1.00	0.98
A 45/89	17.4	19.3	1.43	0.88	24.5	27.8	1.50	0.88
A 46/89	16.5	18.6	1.71	0.91	23.0	25.3	1.12	0.91
A 63/89	18.5	21.2	1.86	0.89	26.1	29.4	1.38	0.89
A 49/85	19.0	21.6	1.71	0.92	26.7	29.1	1.00	0.92
A 131/85	16.8	18.1	1.14	0.86	22.6	26.3	1.75	0.86
A 39/85	19.6	21.3	1.14	0.92	27.0	29.2	1.00	0.92
F 472 M3-1	19.3	19.0	0.14	1.05	26.7	25.3	0.12	1.05
Plai	20.3	20.5	0.14	1.00	26.1	26.0	0.00	1.00
Gloria	20.5	20.3	0.14	1.01	27.5	27.3	0.00	1.01

AL = albic luvisoil; BL = brown luvic soil

adaptability to the specific conditions of podzols (Table 2). The stress index reveals that the Albota and Ariesan cultivars as well as the A 74-86, A 3-89, A 8-88, A 62-89, A 7-89, F 472 M 3-1 lines have close values with those of Atlas 66 control (0.14-0.28) tolerant to the aluminium ion toxicity (Table 2). As a results of the experimentation, we can conclude that the aluminium ions from the albic luvisoil less influenced the root growth of Atlas 66, Albota, Ariesan, A 74-86, A 3-89, A 8-88, A 62-89, A 7-89, and F 472 M 3-1 genotypes. The root growth difference of these lines as compared with Atlas-66 cultivar is, first of all, due to their genetical constitution regarding the root length, phenomenon emphasized by the very low values of the stress index, too.

In the case when the root length of the tested genotypes was determined after 30 days from germination, on the albic luvisoil, significant gains were registered only by Albota, Trivale, A 36-85, A 2-88, A 3-89, and A 135-86 genotypes as compared with Atlas 66 control. Fundulea 4, Fundulea 29 and Lovrin 34 cultivars registered the lowest root lengths in the presence of aluminium ions (Figure 4). On the brown luvic soil, almost all genotypes achieved very significant growth gains as compared with Atlas 66 cultivar (Figure 4), meaning that, excepting Lovrin 34 cultivar, the other genotypes have a better developed root system than Atlas 66 cultivar. In this case, the chemism of this soil, does not negatively influence the wheat root growth.

The stress index values to the aluminium ion toxicity allowed to establish that after 30 days of vegetation, Atlas 66, Albota, Ariesan, A 36-85, A 3-89, A 8-88, and F 472 M 3-1 genotypes have a better tolerance to aluminium ion toxicity, this index having values for the root length bellow 0.25. The A 2-88 and A 135-86 lines were less influenced by the presence of aluminium ions into soil (Table 2). The Atlas 66, Albota, A 8-88 and F 472 M 3-1 genotypes had the best tolerance to aluminium ions from the albic luvisoil, tolerance index = 1, meaning that the root length was equal on both soils (Table 2).

The testing on soil in Mitcherlich pots during 10 or 30 days, lead to the following conclusions:

– on brown luvic soil, after 10 days of experimentation, 19 genotypes had a more developed root system than Atlas 66 cultivar but after 30 days of experimentation, Atlas 66 cultivar exceeded all experimental genotypes, excepting the Lovrin 34 one. The result is due to the fact that the tested lines and cultivars have a very good growth rhythm under conditions of a soil without aluminium ions.

– the presence of aluminium ion excess into albic luvisoil during the first ten days from emergence, hinders the manifestation of the root growth potential to many genotypes, excepting the Albota, Plai, Gloria cultivars as well as the A 103-86 line. This situation emphasizes the importance of this testing method of breeding material. As regards the tolerance to aluminium ion toxicity after 30 days of growing these genotypes in Mitcherlich pots on albic luvisoil, the situation is different. A greater number of genotypes such as Albota, Trivale, Ariesan, A 36-85, A 2-88, A 3-89, A 135-86 and A 10-89 achieved longer roots than Atlas 66 cultivar.

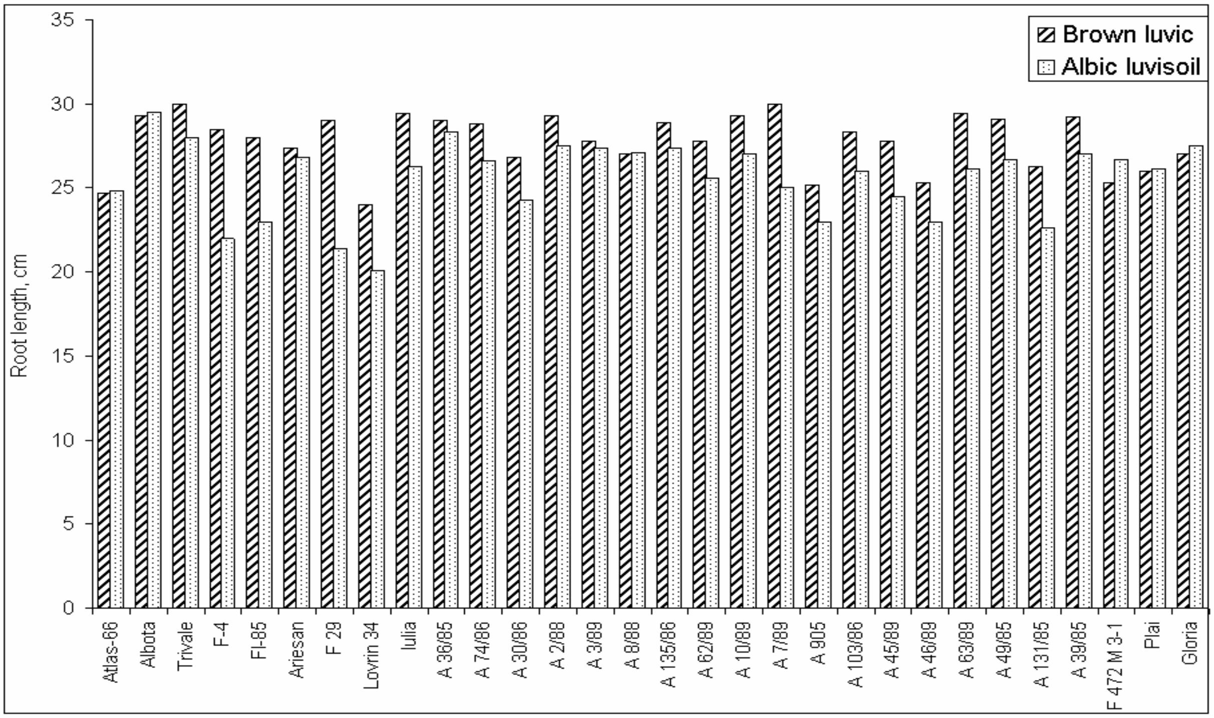

Figure 4. Length of root genotypes cultivated on albic luvisoil and brown luvic soil (Mitcherlich pots, 30 days)

The root length differs among the genotypes, having another genetic determinism than the tolerance to aluminium ion toxicity. In the case in which the Al3+ ions were not present in distilled water, the root length ranged between 100 and 150 mm, lots of genotypes having a vigorous root system exceeding those of Atlas 66, Albota and F 472 M 3-1 cultivars (Figure 5).

At the concentration of 4 ppm Al^{3+} the root length of the majority of genotype released at Pite°ti-Albota, was up to 50 mm, without to reach the level of the most tolerant cultivar, Atlas 66, being comparable with Albota one. The Fundulea 4, Flamura 85, Lovrin 34, A 30-86, A 103-86, A 63-89 and A 46-89 had root length comparable with the Fundulea 29 untolerant cultivar. The F 472 M 3-1 line approached by the to-lerance level of the Atlas 66 cultivar (Figure 5).

Among the tested genotypes, at the concentration of 8 ppm Al^{3+} only the F 472 M 3-1 line achieved increases close to those of Atlas 66 tolerant cultivar. The Albota and Ariesan cultivars and six lines released at Albota, registered increases of a few mm (Figure 6).

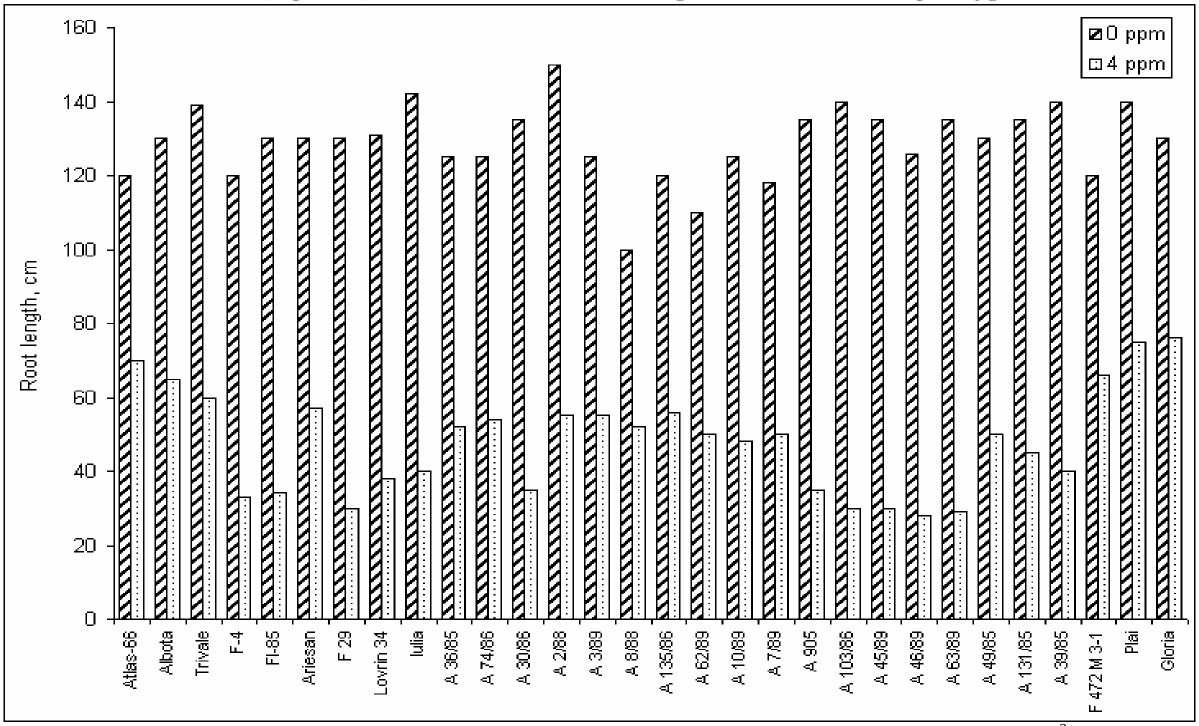

Figure 5. Length of root genotypes cultivated on hydroponic solutions with 0 and 4 ppm Al^{3+} (distilled water + $AlCl_3$ x 6 H_2O)

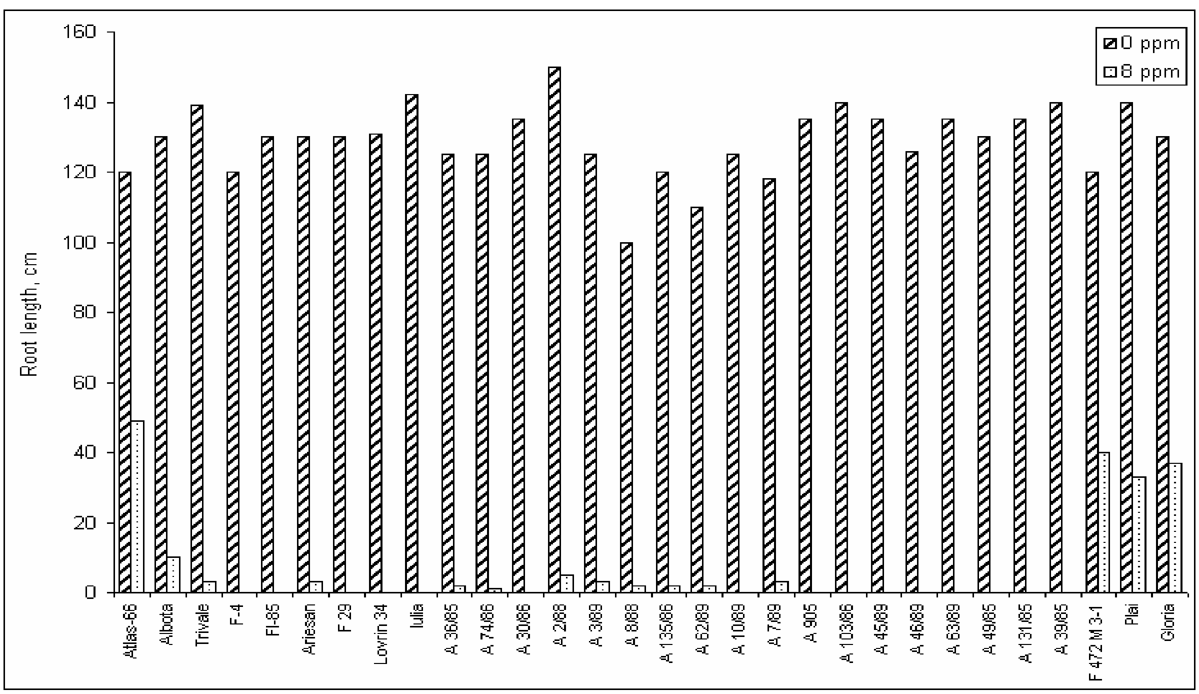

Figure 6. Length of root genotypes cultivated on hydroponic solutions with 0 and 8 ppm Al^{3+} (distilled water + $AlCl_3$ x 6 H_2O)

With a view to eliminate the influence of root development rhythm on the estimation of tolerance to aluminium ion toxicity, the stress index proposed by Fischer and Maurer (1978), was utilized. By this estimation the Atlas 66, Gloria, Plai, F 472 M3-1 and Albota genotypes proved to be superior to the other genotypes with subunitary stress indices to Al^{3+} (Table 3). In this case, the classification of genotipes as tolerant and untolerant, was performed depending on the root length exposed to different aluminium ion concentrations. Thus, Atlas 66, Albota, F 472 M3-1, Gloria and Plai as well as the A 8-88 line were tolerant to 4 ppm Al^{3+}, while A 36-85, A 74-86, A 2-88, A 3-89, A 135-86, A 62-89 and A 7-89 lines as well as Arie san and Trivale cultivars behaved as medium tolerant, and Fundulea 29, Fundulea 4, Flamura 85, Lovrin 34, A 30-86, A 103-86, A 63-89 and A 46-89 cultivars, were sensitive (Table 3).

At the concentration of 8 ppm Al^{3+}, only Atlas 66 cultivar and F 472 M 3-1 line were tolerant, Albota cultivar was medium tolerant and the rest of genotypes stopped practically the root growth. The tolerant or medium tolerant genotypes at 4 ppm Al^{3+}, close to that of Albota cultivar, were chosen as genitors.

In order to choose the genitors with an increased yielding ability and with tole rance to aluminium ion toxicity, the first testing method in Mitcherlich pots (ten days) and the testing on nutritive solutions with 4 ppm Al^{3+} will be utilized. The last method much better discriminates the tolerant genotypes from untolerant ones, using as separation measure the stress index calculated for both root length and yield (Table 3).

The results obtained by the utilization of these methods emphasized the fact that to a genotype tolerant to soil aluminium ions (Atlas 66) corresponds a low stress index for root length in both Mitcherlich pots and nutritive solutions and a low stress index for yield obtained in field on the same soil type (Table 3).

Based on of these research, the genitors with tolerance to aluminium ion toxicity and with other valuable agronomical traits, such as: big spike number/m^2, increased spike weight and big grain number into spike, short plant height, were kept. In order to release wheat cultivars with an increased genetic potential and tolerant to aluminium ions, the following genotypes were chosen: Atlas 66, F 472 M 3-1, Albota, A 36-85, A 135-

Table 3. Sensitivity indices to Al^{3+} for a few traits and features of some winter wheat cultivars and lines obtained during 1989–1992 at ARDS Pitesti-Albota

Variants	Root length				Yield	Spike number/m^2	Grain number/m^2	Grain weight/spike	Height
	Nutritive solutions with Al^{3+}		Mitcherlich pots						
	4 ppm	8 ppm	10 days	30 days					
Atlas 66	0.67	0.62	0.14	0.00	0.71	0.96	0.80	0.39	0.67
Albota	0.79	0.97	0.28	0.00	0.93	0.96	0.70	0.93	0.67
Trivale	0.90	1.03	1.57	0.87	1.03	1.25	2.10	1.07	0.71
Fundulea 4	1.14	1.05	2.57	2.87	1.31	1.00	2.35	1.75	1.29
Flamura 85	1.17	1.05	2.71	2.25	1.24	1.08	1.25	1.46	1.04
Arie°an	0.88	1.03	0.57	0.25	0.96	0.96	1.25	0.86	1.14
Fundulea 29	1.22	1.05	1.85	3.25	1.20	1.00	1.85	1.29	1.38
Lovrin 34	1.13	1.05	2.00	2.12	1.18	1.25	2.20	1.29	1.57
Iulia	1.14	1.05	1.86	1.38	1.04	0.88	0.60	1.14	1.33
A 36/85	0.92	1.03	0.86	0.25	0.87	0.96	0.40	0.71	0.95
A 74/86	0.90	1.04	0.28	1.00	0.88	0.83	0.60	0.86	0.95
A 30/86	1.17	1.05	1.43	1.12	1.04	1.00	1.10	1.06	1.00
A 2/88	1.00	1.02	0.71	0.75	0.88	0.75	0.95	0.93	1.19
A 3/89	0.89	1.02	0.14	0.25	0.91	0.96	2.15	0.79	0.86
A 8/88	0.76	1.03	0.14	0.00	0.93	0.98	1.60	0.93	0.71
A 135/86	0.84	1.03	0.86	0.62	0.88	1.13	0.00	0.71	0.71
A 62/89	0.87	1.03	0.14	1.00	0.98	0.83	0.15	1.04	0.86
A 10/89	0.98	1.05	1.43	1.00	1.09	1.08	2.00	1.14	0.81
A 7/89	0.92	1.02	0.28	2.12	0.98	1.04	1.65	0.96	0.76
A 905/80	1.17	1.05	1.14	1.12	1.16	1.34	0.95	1.04	1.23
A 103/86	1.25	1.05	1.00	1.00	1.11	1.17	1.70	1.11	1.52
A 45/89	1.24	1.05	1.43	1.50	1.11	1.04	2.10	0.89	1.33
A 46/89	1.24	1.05	1.71	1.12	1.07	1.17	2.15	0.89	1.38
A 63/89	1.25	1.05	1.86	1.38	1.00	1.13	0.80	0.64	1.33
A 49/85	0.98	1.05	1.71	1.00	1.04	0.96	1.65	1.07	0.62
A 131/85	1.06	1.05	1.14	1.75	1.02	0.96	1.60	1.21	0.86
A 39/85	1.13	1.05	1.14	1.00	1.02	0.96	0.90	0.89	0.95
F 472 M 3-1	0.71	0.71	0.14	0.62	0.64	0.83	0.10	0.50	0.90
Plai	0.73	0.80	0.14	0.00	0.98	0.50	1.55	1.00	0.24
Gloria	0.73	0.76	0.14	0.00	0.60	0.54	1.70	0.64	0.52

86, A 74-86, A 2-88, A 8-88, A 3-89, A 7-89 and A 62-89. The Trivale, Fundulea 4, Flamura 85 and Ariesan cultivars were utilized as recurrent forms into some hybrid combinations (Table 3).

The utilization of tolerant genotypes (Atlas 66 and F 472 M 3-1) as sources for breeding the tolerance to aluminium ion toxicity in crossings with medium tolerant genotypes (Albota, Ariesan, A 36-85, A 74-86, A 2-88, A 3-89, A 8-88, A 135-86, A 62-89 and A 7-89) or untolerant but intensive ones and with a good adaptability to the pedoclimatic conditions from the North of Romanian Plain (Trivale, Fundulea 4 and Flamura 85), contri-buted to the obtainment of a valuable wheat germplasm which recombines the good yield potential with resistance to lodging and diseases, medium precocity, breadmaking qualities and with tolerance to aluminium ions.

CONCLUSIONS

By testing the Romanian winter wheat germplasm to aluminium ion toxicity on nutritive solutions with different Al^{3+} concentrations, none genotype with genetical tolerance similar to that of Atlas cultivar, was identified.

From the Romanian germplasm, only the F 472 M3-1 line, released at A.R.D.I. Fundulea as part of a special transfer programme for tolerance to aluminium ion toxicity from the Brazi-lian germplasm, showed an increased tolerance level, but it was inferior to Atlas 66 cultivar.

Among the Romanian cultivars, a better tolerance level, but significantly inferior to Atlas 66 cultivar, had the Albota cultivar, selected under natural conditions of podzol.

By testing the a great number of winter wheat cultivars released at A.R.D.I. Fundulea and its research station network, cultivars were identified as Albota, Trivale, Ariesan, with both well-developed root system and good growing rhythm on albic luvisoil, very important traits for increasing the tolerance to aluminium ion toxicity.

Among the lines obtained at A.R.D.S. Pitesti-Albota, a number of eight lines were identified (A 2-88, A 3-89, A 8-88, A 7-89, A 36-85, A 135-86, A 74-86, A 62-89) with good adaptability to acid soil and with tolerance to 4 ppm Al^{3+} concentrations, these lines being an important source of germplasm for increa-sing the tolerance to aluminium ion toxicity.

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Table 1. Reproduction ability of the *E. integriceps* recent generations, as compared with multiannual average (1970-2000) and with the specific years: favourable (1986) and unfavourable (1989).

Natural generation of *E. integriceps*	Prolificacy (egg/female)		
	under field conditions	under controlled conditions	
		average	maximum/female
1970-2000	40.2	57.9	311
1986	56.3	71.3	298
1989	18.8	27.1	87
1996	47.1	69.9	302
1997	46.6	68.6	197
1998	37.5	53.8	209
1999	38.8	54.5	219
2000	39.3	55.7	208

Table 2. Prolificacy level of some *E. integriceps* populations (fertile females), from generations with different fat body levels, collected from the field, at the beginning of migration and studied under controlled conditions.

Fat	Generation	Prolificacy

body		(egg/female)	
		aver-age	maxi-mum
23.4	1989-1990	32.1	97
22.5	1972-1973	33.4	127
26.5	1971-1972	46.4	148
27.9	1977-1978	67.5	186
28.0	1984-1985	83.6	210
29.7	1985-1986	95.3	234
29.8	1994-1995	104.7	246

Table 3. Level and stages of fat body diminution at *E. integriceps* (multigeneration average).

Stages	Fat body level		Diminution	
	limits	average	limits	average
Diapause beginning	33.03-37.58	35.69	0	0
End of dia-pause	21.97-27.64	25.43	24.57-36.33	27.39
End of ovi-position	8.12-10.39	8.78	66.50-78.69	74.43

Table 4. Mortality registered at the *Eurygaster integriceps* populations, during diapause in different generations, from Romanian area

E. integriceps natural popula-tion	Mortality (%)	
	Limits in coun-ties	Total area (mean)
2000-2001	4.6-35.7	8.7
1995-1996	3.7-36.4	10.2
2001-2002	5.1-32.3	12.7
1985-1988	3.8-41.2	14.8
1999-2000	4.8-97.6	24.5
1973-1974	11.6-85.0	39.5
1988-1989	17.5-68.4	48.2

Table 5. Fat body value at *Eurygaster integriceps* populations, established on female groups, distributed in weight classes, at the beginning of diapause (multigeneration average).

Weight (mg)	% from the total of population		Fat body (%)	
	limits	average	limits	average
below 0.110	3.7-7.7	5.6	26.2-26.6	26.4
0.111-0.118	7.6-23.1	13.3	26.5-28.8	28.7

0.119-0.126	15.9-24.7	19.7	32.8-33.5	33.6
0.127-0.134	32.5-34.8	33.7	34.9-36.4	35.4
over 0.145	22.4-30.8	28.6	35.7-39.8	38.7

Table 6. Fat body value at *Eurygaster integriceps* populations, established on male groups, distributed in weight classes, at the beginning of diapause (multigeneration average).

Weight (mg)	% from the total of population		Fat body (%)	
	limits	aver-age	limits	aver-age
below 0.105	7.0-19.7	12.3	25.3-26.7	26.2
0.106-0.113	16.8-19.9	17.3	27.2-28.5	27.7
0.114-0.121	20.3-29.5	23.7	29.4-33.8	31.5
0.122-0.129	19.2-32.7	28.5	31.2-35.5	32.6
over 0.130	15.5-23.9	19.4	31.4-36.6	33.8

Table 7. Mortality (%) registered at *Eurygaster integriceps* female populations, depending on the fat body (multigeneration average).

Fat body (%)	Mortality (%)			
	During August-October		During November-March	
	limits	average	limits	average
26.4	17-22	20.4	59-64	61.3
28.7	13-15	12.9	43-54	47.6
33.6	9-17	12.5	41-52	46.2
35.4	4-11	6.6	29-34	33.6
38.7	4-7	5.8	26-35	30.9

Table 8. Mortality (%) registered at *Eurygaster integriceps* male populations, depending on the fat body (multigeneration average).

Fat body (%)	Mortality (%)			
	During August-October		During November-March	
	limits	average	limits	average
26.2	22-31	22.6	62-71	67.1
27.7	11-24	20.4	53-62	57.4
31.5	12-19	14.3	39-47	44.0
32.6	9-18	12.7	30-44	37.6
33.8	5-14	9.1	24-45	32.3

Table 9. Sterility and prolificacy registered at the *Eurygaster integriceps* populations, depending on the fat body (multigeneration average).

Fat body (%)	Females sterility (%)		Mean prolificacy (egg/female)		
	limits	aver-age	limits	aver-age	maxi-mum
26.4	100	100	0	0	0
28.7	60-72	63.5	4.1-6.6	5.4	42
33.6	54-63	57.3	16.2-22.8	19.5	78
35.4	35-44	39.1	26.4-33.1	30.3	135
38.7	25-32	29.8	38.9-51.7	45.8	194

Table 10. Multiplication index at the *Eurygaster integriceps* populations, depending on the fat body (multigeneration average).

Fat body (%)	Multiplication index (egg/female)	
	limits	average
26.4	0	0
28.7	0.37–2.47	1.54
33.6	4.54–9.62	6.95
35.4	28.57–40.18	35.22
38.7	49.38–64.83	56.47