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Evaluating Aluminum Toxicity Tolerance in Wheat Cultivars Based on Root Traits

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Abstract: *In order to evaluate the aluminum toxicity tolerance in wheat cultivars, 20 wheat cultivars in three aluminum stress levels (control, 20 µM and 40 µM Al3+) were studied in greenhouse of Mohaghegh Ardabili University at 2014. The experiments conducted as factorial experiment based on completely randomized design with three replicationsin at hydroponic systems. Analysis of variane showed significant differences between stress levels, cultivars and interaction of stress and cultivars in all studied trait. This showed genetic diversity of wheat cutivars in root traits and different response of cultivars to stress levels. Grouping of the wheat varieties using Ward method in non stress and two stress conditions separate the varieties in two different groups. In control and 20 µM Al3+ stress conditions the varieties of 1, 2, 3, 4, 5, 7, 9 and 10 had higher root length and other root chracters in compared with other varieties. But, in 40 µM Al3+ had low amount for meseared traits. This showed that these varieties were susceptible to Al3+ toxicity. The means of root chracters of first group with three sub groups in 40 µM Al3+ stress condition were higher than other group. The subgroup containing of varieties 19 and 20 had higher root length, weight, volume and surface. These two varieties in control condition belonged to first group with high amounts of means*.

Keywords: *Wheat, Aluminum, Resistance*

1. Introduction

Aluminum is one of the most abundant metallic elements in the earth. The dissolving of aluminum in the soil, reduce root systems activity and make significant changes in root morphology. In asid soils, aluminum hydrolysed to Al3+ and becomes the limiting factor to growth and production of plants. Inhibition of root growth is the first sign of aluminum toxicity (Chen et al. 2005). In aluminum stress condition the roots usually become short, brittle and brown, and the absorption of water and nutrients are inefficient (Sun et al. 2010, Arroyave et al. 2011). Changes in the level and composition of the plasma membrane lipid (Horst et al. 2010), increasing of oxidative stress (Bhuja et al. 2004), formation and accumulation of callose (Ahan et al. 2002) and disruption of the cell cytoskeleton dynamics (Fangjie et ah 2010) are the signs of Aluminum toxicity to roots.

Heavy metals Prevente plant growth with different methods. This metals reduces photosynthesis, assimilate transfering and cell division. The primery effect of heavy metals toxicity is the peroxidation of lipids, formation of Malone-de aldehyde and modification of cell membranes building (Molassiotis et al. 2005). In wheat tow loci identified on chromosomes 4DL and 4BL that control tolerance to aluminum toxicity (Ryan et al. 2010). This study was performed to study genetic diversity of wheat cultivars to aluminsity based root traits.

2. Materials and Methods

This experiment was done in greenhouse of Mohaghegh Ardabili University at 2014 in a hydroponic system. Twenty wheat cultivares (table 1) in three Aluminum stress levels (Hoglang solution as control and Hoglang solution+ 20 µM and 40 µM Al3+) were studied in a factorial experiment based on completely randomized design with 3 replications in hydroponic system. Seeds were germinated in an incubater at 7ºC for 84 h then 24 ºC for 24h. After germination, uniform seedlings were established in a hydroponic system. The control plants

were sown in hogland solution (table 2). In stress treatments plant sown in hogland solution containing 20 µM and 40 µM Al3+, obtained from AlCl3. Ten days after sowing root length (RL-cm), root fresh (RFW) and dry wieght (RDW) (gr), root volume (RV-cm3) and root surface (RS) based on Etkinsons method mesaerd as fallow:

root surface = 2*{(root volum, cm3)*3.14*(root length, cm)}0.5

Analysis of data was don using SPSS16 software and drowing of graphs were done using Excel softwares. Cluster analysis was done suing Ward method.

3. Results and Discissions

Analysis of variane showed significant differences between stress levels, cultivars and interaction of stress and cultivars in all studied trait. This showed genetic diversity of wheat cutivars in root traits and different response of cultivars to stress levels. In studied traits the lowest coefficient of variation (19.71%) belong to root surface and the highest coefficient of variation (29.42%) belong to root volum (table 3). The interaction of variety and stress levels was significant. For this, comparition of means was done separatly in control and tow stress levels (table 4). Means in control and tow stress leve showed that 40 µm Al3+ toxicity in reduced all traits of roots. In aluminum stress condition the roots usually become short, brittle and brown, and the absorption of water and nutrients are inefficient (Sun et al. 2010, Arroyave et al. 2011). Grouping of the wheat varieties using Ward method in non stress and two stress conditions separate the

TABLE I:The name of wheat cultivares that used in this experiment

No.	Name	No.	Name	No.	Name	No.	Name
1	Moghan1	6	Shiroodi	11	Saisson	16	BC Roshan
2	Moghan2	7	Kavir	12	Inia	17	Rasoul
3	Moghan3	8	Darya	13	Zarrin	18	Tajan
4	Arta	9	Arg	14	Tous	19	Gascogen
5	Atrak	10	Arum	15	Gaspard	20	Mihan

TABLE II: The consentration of Hogland solution that used in this study

No.	Material	Consentration (µmol)	No.	Material	Consentration (µmol)
1	$Ca(NO_3)_2$	2500	6	H_3BO_3	23
2	KNO_3	300	7	$MnSO_4$	5
3	$Mg\ SO_4$	1500	8	$ZnSO_4$	0/4
4	KH_2PO_4	1700	9	$CuSO_4$	0/2
5	$Fe\ SO_4$	50	10	H_2MoO_4	0.1

TABLE III: Analysis of variance for root traits of wheat in hydroponic system at Al stress condition.

SOV	df	Mean of Squares				
		Rl	RFW	RDW	RV	RS
Stress (S)	2	470.74^{**}	0.014^{*}	0.0068^{**}	2.89^{**}	379.41^{**}
Variety (V)	19	52.12^{**}	0.027^{**}	0.0063^{**}	0.77^{**}	54.18^{**}
S*V	38	106.56^{**}	0.013^{**}	0.0028^{*}	0.57^{**}	59.19^{**}
Error	120	9.36	0.004	0.0013	0.30	12.89
CV (%)		20.28	28.84	24/72	29.42	19.71

ns, * and ** nonsignificant and significant at 5 and 1 precent probailty level, respectively.

varieties in two different groups (Fig 1, 2 and 3). The means of obtained groups and total means for meseard traits showed in table 5. In control and 20 µM Al3+ stress conditions the varieties of 1, 2, 3, 4, 5, 7, 9 and 10 had higher root length and other root chracters in compared with other varieties. But, in 40 µM Al3+ had low amount for meseared traits. This showed that these varieties were susceptible to Al3+ toxicity. The means of root chracters of first group with three sub groups in 40 µM Al3+ stress condition were higher than other group. The subgroup containing of varieties 19 and 20 had higher root length, weight, volume and surface. These two varieties in control condition belonged to first group with high amounts of means.

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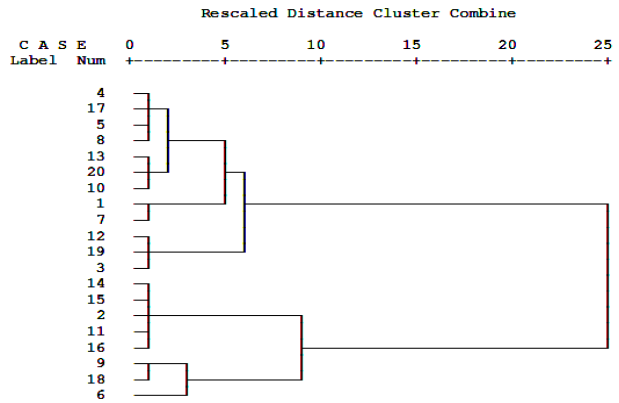

Fig. 1. Grouping of the wheat varieties using Wards method in non stress (control) conditions

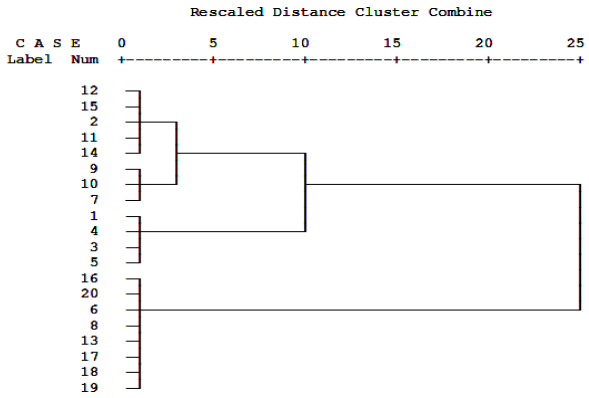

Fig. 2. Grouping of the wheat varieties using Wards method in 20 µM Al^{3+} conditions

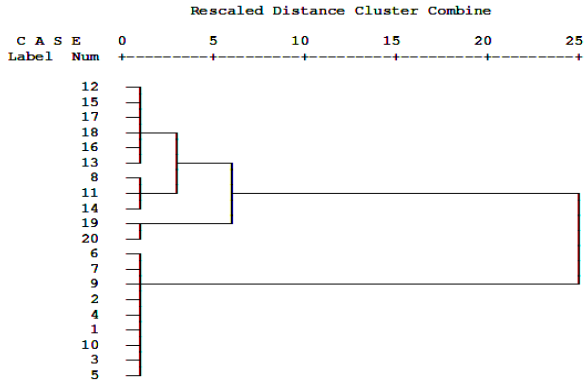

Fig. 3. Grouping of the wheat varieties using Wards method in 40 µM Al3+ conditions

TABLE IV. Means of wheat varieties and $LSD_{0.01}$ value for meseared traits in control Al toxicity conditions

	Control (Hogland solution)					Hogland solution and 20 µm Al^{3+}					Hogland solution and 40 µm Al^{3+}				
Variety	Rl	RWW	RDW	RV	RS	Rl	RWW	RDW	RV	RS	Rl	RWW	RDW	RV	RS
1	17.1	0.2267	0.014	3	25.1787	20.1667	0.28	0.018	3.3333	29.046	5.6333	0.1537	0.01133	2	11.6293
2	17	0.1933	0.014	1.0667	14.9407	17.2667	0.241	0.015	1.8333	19.8827	6.6667	0.111	0.00867	1.6667	11.6993
3	24.0667	0.3133	0.02067	1.6667	22.1233	25.0333	0.43	0.02367	2.8333	29.7287	6.1	0.2087	0.01733	1.6667	11.2133
4	19.8	0.2467	0.016	1.4	18.4953	20.2	0.216	0.01333	2.6667	25.868	7.3667	0.1487	0.011	1.6	11.504
5	19.6	0.21	0.01433	2	21.4313	23.9	0.32	0.01767	2.1	25.086	6.3	0.1213	0.01067	1.5	10.728
6	9.4333	0.1433	0.00867	1	10.6613	12.6	0.167	0.01467	1.6667	15.6567	5.0667	0.0913	0.00867	1.5	9.74
7	13.7	0.2067	0.01267	3.1667	23.14	22.4	0.2597	0.014	1.3333	19.148	4.1667	0.125	0.00967	1.4333	8.4013
8	20	0.1433	0.01467	1.6667	20.3647	14	0.2503	0.01233	1.5	15.848	10.8333	0.1833	0.01167	1.7333	15.3453
9	10.5667	0.16	0.01367	2	16.1333	21	0.273	0.017	1.7333	21.2273	3.5	0.1923	0.01267	2.1667	9.7107
10	16.2667	0.2633	0.01833	1.8333	19.2233	19.2667	0.2283	0.014	1.9	21.324	5.8667	0.167	0.012	1.8333	11.4893
11	17.1667	0.2467	0.01233	1.3667	16.8113	14.5667	0.196	0.01167	2.1667	19.8633	11.7333	0.1637	0.01067	1.7333	15.8467
12	21.9667	0.37	0.019	2.2333	24.7876	16.3667	0.3367	0.01533	1.9667	19.6467	17.0333	0.374	0.021	1.8333	19.7693
13	17.6667	0.3733	0.01833	1.9	20.2427	11.1	0.2747	0.01433	1.9	16.244	13.7667	0.2913	0.01227	2.5	20.7367
14	17.2667	0.2267	0.014	1.1667	15.5913	13.6	0.1687	0.00833	2.5	20.634	11.2	0.1483	0.00867	1.5	14.4027
15	17.5667	0.2267	0.01567	1.1333	15.7933	16.3667	0.2437	0.01367	2.0333	20.4287	17.2333	0.3443	0.01933	1.8333	19.8453
16	18.3333	0.1933	0.014	1.3333	17.2853	7.9667	0.1697	0.01567	2.2	14.662	20.1	0.2833	0.01333	1.5333	19.2953
17	19.6	0.25	0.017	1.5	18.736	10.2667	0.2627	0.01833	2.1667	16.5493	18	0.2243	0.01767	1.7333	19.528
18	12.5	0.2	0.015	1.7667	16.5773	11.4333	0.108	0.01533	2.1	17.2333	18.3	0.1727	0.01233	1.6667	19.2053
19	21.0333	0.28	0.01767	2.1333	23.664	10.9	0.1077	0.01633	2.7667	19.3253	25.5667	0.3017	0.02033	1.7667	23.814
20	17.6	0.2067	0.016	2.1667	21.848	9.1333	0.07	0.01333	2.1667	15.5287	25.1333	0.3057	0.018	1.8333	23.6873
$LSD_{0.01}$	7.670	0.090	0.964	0.160	7.672	11.120	0.117	1.024	0.165	9.357	12.12	0.148	1.123	0.164	9.804

TABLE V: The groups obtained in control and two stress condition using Ward method and those means for meseard traits.

	group	variety	Rl	RFW	RDW	RV	RS
Cotrol	1	1,3,4,5,7,8,10,12,13,17,19,20	19.03	0.26	0.016	2.05	21.6
	2	2,6,9,11,14,15,16,18	14.98	0.199	0.013	1.35	15.5
	total	-	17.41	0.23	0.015	1.77	19.15
20 µM Al^{3+}	1	1,2,3,4,5,7,9,10,11,12,14,15	19.18	0.27	0.01513	2.19	22.66
	2	6,8,13,16,17,18,19,20	10.92	0.18	0.01504	2.05	16.38
	total	-	15.88	0.23	0.01509	2.14	20.15
40 µM Al^{3+}	1	8,11,12,13,14,15,16,17,18,19,20	17.17	0.25	0.0150	1.79	19.22
	2	1,2,3,4,5,6,7,9,10	5.63	0.15	0.0113	1.71	10.68
	total	-	11.98	0.20	0.0134	1.75	15.38