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Nutrients decrease Al toxicity to resistant variety of wheat (Raj-3077)

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Abstract: *Wheat is a second major staple food crop in south Asia after, rice. The wheat acreage to South Asia (India, Pakistan, Nepal, and Bangladesh) is more than 36 million hectare (FAO 2007). But it is also seems less to fulfill the needs of population. Different environmental factors and pollutants decrease its yield further. Aluminum decreases its root- shoot length and biomass at different concentrations; but nutrient supply decreases the toxic effects.*

I. Introduction

Aluminum is found natural in soil, water, air (CEPA, 2000; ATSDR, 2006). Al ion contributes to soil acidity through their tendency to hydrolyze. The hydrogen ions released give a very low pH value in the soil solution and are a major source of hydrogen in most acid soils (Richard, 1998). Aluminum (Al) is toxic to plants at low pH and can begin to inhibit root growth within 3 h in solution experiments and finally decrease in yield. Al interferes with uptake or transport and utilization of essential nutrients like Ca, Mn, P, Mg, B, Fe, Cu, K, and Zn (Keltjens and Tan, 1993; Keltjens, 1995; Lukaszewski and Belvins, 1996; Slaski *et al*, 1996; Taylor *et al*, 1998; Lidon *et al*, 2000; Guo *et al*, 2003, 2007; Olivares *et al*, 2009).

II. Material and method

Plant Materials

Wheat (*Triticum aestivum)* Raj-3077 is an early maturity (115-120 days) medium height (90 cm) variety, released in Rajasthan, 1989 under wheat Breeding Scheme, RAU, ARS, Durgapura. It is resistant to brown and yellow rust, tolerant to Saline and alkaline conditions and well adapted to drought. Its grains are lustrous amber medium bold semi-hard with good chapatti making quality.

Seeds were surface sterilized with 0.1% mercuric chloride ($HgCl_2$). Equal sized seeds were sown at equal distance in Petri dishes lined with filter paper and germinated in dark at 25±5° for 24 h.

Preparation of stock solution of Aluminum

1000 ppm stock solution was prepared with Analar grade aluminum sulphate **(**$Al_2 (SO_4)_3.16H_2O$). Various dilutions were prepared using distilled water and Hoagland's Solution respectively.

Hoagland's' medium composition

KH_2PO_4, KNO_3, $MgSO_4.7H_2O$, Boric acid, $MnCl_2.H_2O$, $ZnSO_4.7H_2O$, $CuSO_4.5H_2O$, Molybdic acid, Fe-EDTA make up to one liter of solution.

Treatments for wheat

Group A- Al solutions (100, 250, 500, 750, 1000ppm) made in distilled water; Group B- Al solutions (100, 250, 500, 750, 1000ppm) made in Hoagland's nutrient medium. Group A control was set in distilled water whereas of Group B in Hoagland's nutrient solution.

Growth conditions

The plants were grown under 500 watt fluorescent light bulb. This light stayed on for 10 hours a day for 10 days. Harvesting was after 10 days. Root numbers were counted while root-shoot lengths were measured with the help of scale. Roots and shoots were separated and oven dried at 60°C for two days. Dry weight was taken after two days on electronic balance.

III. Result

Toxicity of different concentrations of Al on wheat

Germination was recorded 95-100% at all concentrations i.e. no adverse effect on germination. Symptoms of toxicity were noted at high concentrations of Al, reduced development of the roots, stubby appearance and were brownish color. Above ground portion of the plant, typical symptoms are small leaves, and shortened and thickened internodes

There was dose dependent reduction in root number, shoot and root length and their dry weight, with the exception at 100 ppm at which both shoot and root growth were least affected (Table 1). I found 100ppm Al concentration to be non toxic to seedlings. Rather it was favorable to shoot growth.

Toxicity of different concentrations (diluent Hoagland's solution) on wheat

There was no change in shoot number of wheat (*T. aestivum)* but root numbers were higher than control. Maximum (29.0%) number of roots was found at 750 ppm.

Shoot length increased a little at 100ppm and 250ppm but decreased markedly at 750 and 1000 ppm (Table. 2). The root length decreased gradually with increased Al concentration, with exception at 100 ppm showing a little increase (14.5%). The smallest roots were found in seedlings growing at 1000 ppm (Table. 2).

Compared with control, both shoot and root dry weights increased at 100 and 250ppm but decreased at higher concentrations, being minimum at 1000 ppm (Table 2). Similar trend was noted for total dry biomass of seedlings. R/S ratios declined at lower concentrations (100-500ppm) but increased at higher concentrations (750-1000ppm).

Al toxicity was low when different dilutions of Al were made in Hoagland's medium suggesting plant nutrients in the medium provides protection to seedlings.

Table: 1 Toxicity of different concentrations of Al (diluted with distilled water) on wheat seedlings.

	Shoot Number	**Root Number**	**Shoot length (cm)**	**Root Length (cm)**	**Dry weight of shoot (mg)**	**Dry weight of root (mg)**	**Total dry weight (mg)**	**Root/Shoot dry wt. ratio**
Control	1.0+0.0	6.4±0.2	13.2±0.7	11.7±0.8	11.7±0.8	11.2±0.9	22.9±0.9	0.9
100 ppm	1.0±0.0 (Nil)	6.0±0.3 (-6.3%)	15.6±0.7* (+18.2%)	9.2±0.7 (-21.4%)	14.1±1.1 (+20.5%)	11.7±0.1 (+4.5%)	25.8±1.9 (+12.7%)	0.8 (-15.6%)
250 ppm	1.0±0.0 (Nil)	7.4±0.6 (+15.6%)	11.9±1.3 (-12.1%)	6.2±1.1** (-47.0%)	11.5±1.4 (-1.7%)	9.9±0.6 (-11.6%)	21.4±1.8 (-6.6%)	0.9 (-10.4%)
500 ppm	1.0±0.0 (Nil)	7.2±0.4* (+12.5%)	10.6±0.6 (-19.7%)	5.3±0.4*** (-54.7%)	9.2±0.5* (-21.4)	8.4±0.6** (-25.0%)	17.7±0.7** (-22.7%)	0.9 (-6.3%)
750 ppm	1.0±0.0 (Nil)	7.4±0.5 (+15.6%)	1.7±0.04*** (-87.1%)	1.9±0.5** (-83.8%)	1.9±0.5** (-83.8%)	6.3±0.6* (-43.8%)	8.3±0.9*** (-63.8%)	3.3 (+243.8%)
1000 ppm	1.0±0.0 (Nil)	7.2±0.5 (+12.5%)	1.5±0.4*** (-88.6%)	1.9±0.7*** (-83.8%)	1.9±0.7*** (-83.8%)	5.8±0.8** (-48.2%)	7.8±1.4*** (-65.9%)	3.05 (+217.7%)

*Significance at 5% ** 1% and *** 0.1% probability, data in parenthesis indicate percent change in values in comparison to control

Table: 2 Toxicity of different concentrations of Al (diluted with Hoagland's solution) on wheat seedlings

	Shoot Number	**Root Number**	**Shoot length (cm)**	**Root Length (cm)**	**Dry weight of shoot (mg)**	**Dry weight of root (mg)**	**Total dry weight (mg)**	**Root/Shoot dry wt. ratio**
Control	1.0±0.0	6.2±0.2	10.1±0.4	6.2±0.6	10.1±0.7	11.7±0.8	21.8±0.9	1.2
100 ppm	1.0±0.0	6.4±0.2 (+3.2%)	10.5±0.3 (+3.9%)	7.1±1.0 (+14.5%)	10.7±0.9 (+5.9%)	10.8±0.4 (-7.7%)	21.5±1.1 (-1.4%)	1.0 (-12.9%)
250 ppm	1.0±0.0	7.0±0.4 (+12.9%)	10.9±1.2 (+7.9%)	4.8±0.5 (-22.6%)	11.2±1.4 (+10.9%)	9.7±0.6 (-17.1%)	20.8±1.7 (-4.6%)	0.9 (-25.0%)
500 ppm	1.0±0.0	6.8±0.2 (+9.7%)	10.1±1.7 (Nil)	4.6±0.4 (-25.8%)	9.5±1.7 (-5.9%)	8.4±0.5 (-28.2%)	17.8±1.6 (-18.3%)	0.9 (-24.1%)
750 ppm	1.0±0.0	8.0±0.0** (29.0%)	5.4±0.6** (-46.5%)	3.7±1.0* (-40.3%)	4.5±0.5** (-55.4%)	6.8±0.4** (-41.9%)	11.3±0.6** (-48.2%)	1.5 (+30.2%)
1000 ppm	1.0±0.0	7.4±0.5 (+19.4%)	1.5±0.5** (-85.1%)	2.1±0..2** (-66.1%)	2.0±0.7** (-80.2%)	5.9±0.7** (-49.6%)	8.0±1.3*** (+63.3%)	2.9 (+154.3%)

*Significance at 5% ** 1% and *** 0.1% probability, data in parenthesis indicate percent change in values in comparison to control

IV. Discussion

Aluminum exposure affected plant growth adversely. In the present investigation, Al stress decreased plant height, root length and plant biomass. These findings are in agreement with other workers (Mossor-Pietraszewska, 2001; Ma, 2007; Zheng *et al.*, 2007, Jiang *et al.*, 2008; Diaz, 2011).

Wheat root and shoot growth were affected greatly in Al treatments (250, 500, 750 and 1000ppm) prepared after dilution of stock solution with distilled water (Table 1). Al toxicity at similar concentrations was relatively less when dilutions (250 and 500 ppm) of stock solution were made in Hoagland's nutrient (Table 2). This may be either on account of chelation of Al with EDTA or competition of Al with divalent cations for absorption. Bartlett and Riego (1972) reported same on maize seedlings.

The lower concentration of Al (100ppm) had no adverse effects on wheat seedlings might be due to less Al was accumulated in tolerant wheat (Darko *et al.*, 2004). Kochian (1995) reported that Al might be bound inactively to some component of the cell wall or cell membrane, or to ligands found in the cytoplasm or vacuoles.

V. Conclusion

The lower concentrations were not toxic to Raj-3077 resistant variety of wheat and dilutions made with Hoagland's nutrient medium supports seedling growth and decreased Al toxicity.

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