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Studies of Aluminum (Al_2O_3) Stress on morphology and pigments of *Vigna radiata* L.

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Abstract

Experimental Study of Aluminum (Al_2O_3) Stress on morphology and pigments of *Vigna radiata* ,L. seedlings was conducted with the treatment concentrations being 200, 400, 600, 800 and 1000 mg/L for 7 days. The Low concentration has affected the parameters slightly, but increase in treatment decreased the root and shoot length and pigments. The correlation analysis between Aluminum and pigments showed a significant negative relationship.

Keywords: Aluminum, *Vigna radiata* ,L, Pigments, Seedlings, stress.

Introduction

The most easily recognized symptom of A1 toxicity is the inhibition of root growth, and this has become a widely accepted measure of A1 stress in plants. Al is present in water, soil and air but most of it is incorporated into alumino silicate soil minerals and only very small quantities (at sub micro molar levels) appear in soluble forms capable of influencing biological systems (May and Nordstrom, 1991). The following Al species are toxic for wheat roots in the following increasing order: AlF_{2+} < AlF_{2+} < Al_{3+} < Al_{13}. According to Kochian (1995) opinion toxicity has been convincingly demonstrated only for $Al1_3$ and Al_{3+}Al ions translocate very slowly to the upperparts of plants (Ma et al., 1997a). Most plants contain no more than 0.2 Mg Alg^{-1} dry mass. However, some plants, known as Al accumulators, may contain over 10 times more Al with-out any injury.

Aluminum (Al) is not regarded as an essential nutrient, but low concentrations can sometimes increase plant growth or induce other desirable effects (Foy 1983, Foy and Flemming 1982, Foy et al., 1978). Aluminum toxicity is an important growth-limiting factor for plants in acid soils below pH 5.0 but can occur at pH levels as high as 5.5 in mines poils [Alam and Adams, 1979, Blue and Dantzman 1977, Carvalho et al., 1980, Foy 1974, Foy 1988, Foy 1992, Kamprath and Foy 1985, Roy et al., 1988). Generally, Al interferes with cell division in root tips and lateral roots, increases cell wall rigidity by cross linking pectins, reduces DNA replication by increasing the rigidity of the DNA double helix, fixes phosphorous in less available forms in soils and on root surfaces, decreases root respiration, interferes with enzyme activity governing sugar phosphorylation and the deposition of cell wall polysaccharides, and the uptake, transport, and also use of several essential nutrients (Ca, Mg, K, P and Fe) (Foy 1992). Excess Al even induces iron (Fe) deficiency symptoms in rice (*Oryza sativa* L.), sorghum and wheat (Clark et al., 1981, Foy 1982, Furlani and Clark 1981)

Aluminum toxicity to plants is well known in agriculture and forestry (Wild, 1988). Direct and indirect effects of enhanced aluminum availability in soil due to soil acidification may be cause of current problems in some European forests (Abrahamsen et al. 1994). Numerous studies exist of plants exposed to aluminum in nutrient solution or sand culture. They show that exposure causes diminished root growth and development, reduced uptake of plant nutrient (notably phosphorus, calcium and magnesium) and stunted plant growth (Bartlett and Riego, 1972a,b; Göransson and Eldhuset, 1987; Boxman et al.,1991; Keltjens and Tan (1993). It can act directly on plant cell processes (Taylor, 1991) or indirectly by interfering with plant nutrition (Roy et al., 1988; Taylor, 1991). Plant species vary in their response to aluminum (Roy et al., 1988; Taylor, 1994). Even within species (e.g., wheat, *Triticum aestivum*), aluminum sensitive and tolerant varieties exist (Taylor and Foy, 1985; Kinraide et al., 1992; Huang et al., 1992a; Wheeler et al., 1992). There are reports that aluminum can benefit plants (Hackett, 1962, 1964, 1967). Various proposed mechanisms are listed in the review by Roy et al. (1988). However, it seems that exposure to excessive concentrations of aluminum is detrimental to plants, but the level that is excessive is highly variable.

Aluminum does not affect the seed germination but helps in new root development and seedling establishment (Nosko et al., 1988). Root growth inhibition was detected 2-4 days after the initiation of seed germination (Bennet et al., 1991).Severa1 reviews on Al toxicity are available (Haug 1984; Taylor 1988; Rengel 1992a); here we limit our discussion to the sites of A1 toxicity in higher plants Al ions are taken up by plants mostly through the root system, and only small amounts penetrate the leaves. Most authors now agree that generally the active metal up-take processes involve ion-specific carriers with energy expenditure but a specific Al carrier has not yet been found.

Materials and Methods

Test Chemical & Concentration: The test chemical, Aluminum oxide (Al_2O_3) was used in the seedling stress study was of AR grade and the concentrations selected were 200,400,600,800 and 1000 mg/L of test chemical. The concentrations were chosen basing on our earlier LC 50 study. (Mahapatra et al., 2014)

Test Organism: The prime pulse seed *Vigna radiata*, var.PDM 139 Samart commonly used in eastern state of India, particularly Odisha State has been chosen for study. Healthy seeds of radiation were obtained from OUAT Extension Centre, Ratnapur, Ganjam for the experimentation.

Parameters Evaluated: The seedling parameters studied were root length, shoot length and Pigments (Chlorophyll a, Chlorophyll b, Total Chlorophyll, Carotenoid and Phaeophytin (Arnon,1949) of the seedlings after treatment and seedling growth period of 7 days.

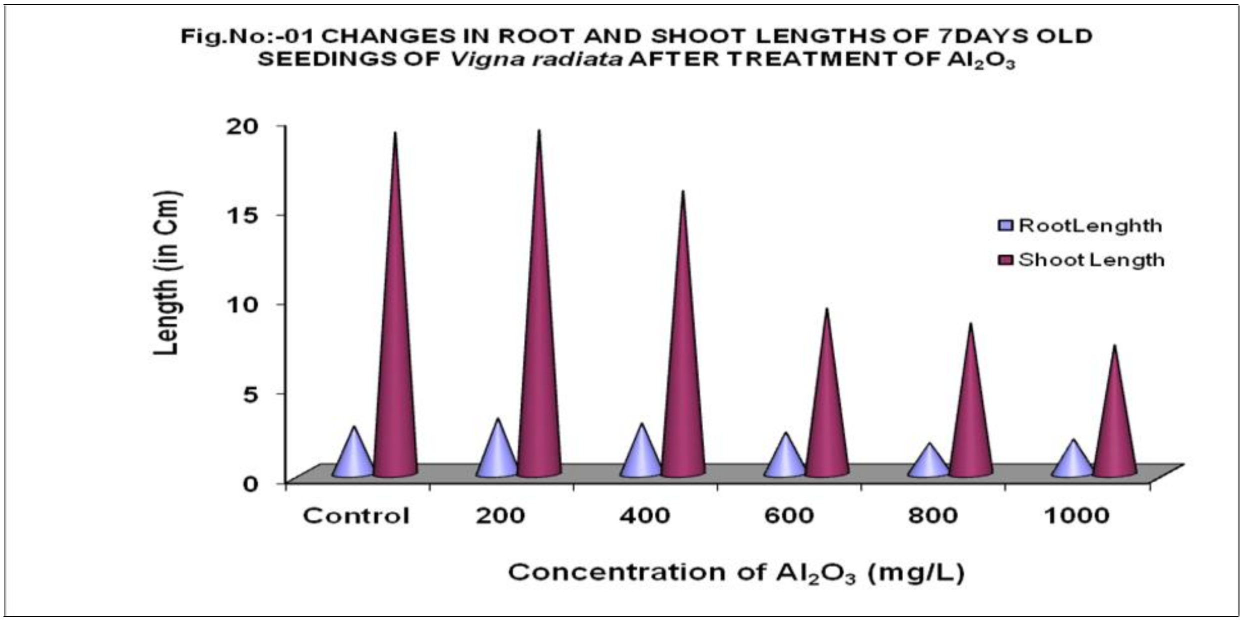
Experiments were conducted in petriplates (6'') with cotton and blotting paper soaked with different concentrations of Aluminum oxide (Al_2O_3).The control set was kept with Al $_2O_3$ free environment. In each concentration of Al_2 O_3, three replicate were taken to find out the % of germination of seeds. The seed germinator (Remi, C-6) was used in experimentation with 25+ 2°C temperature 90% humidity and 12 hours light cycle exposure.

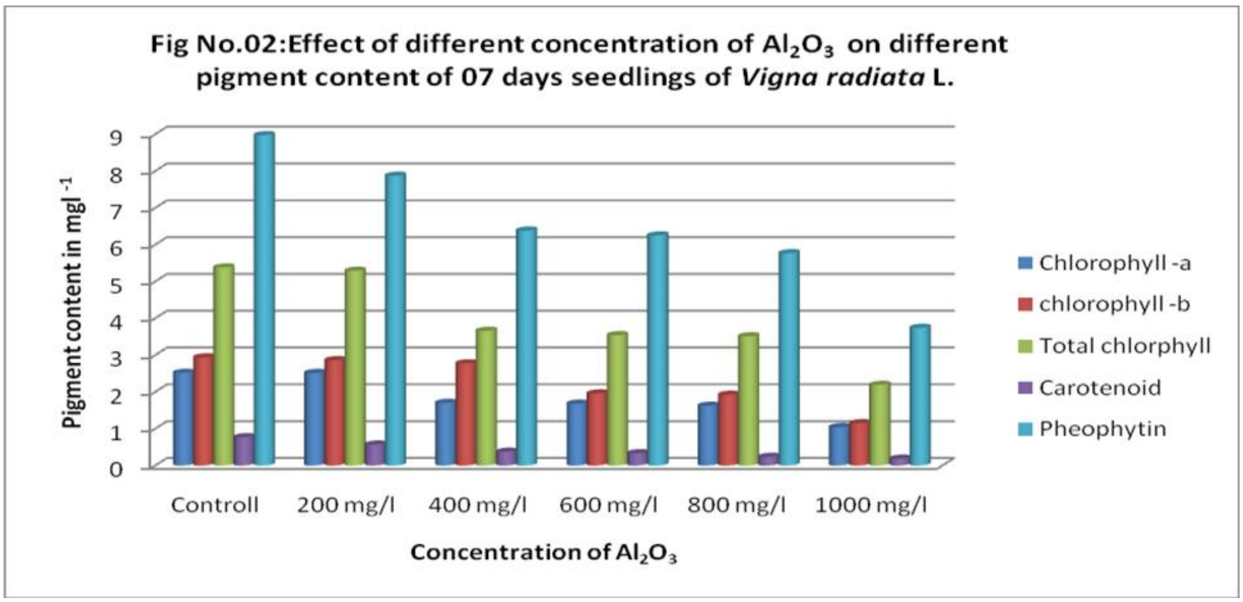
Results

The observations after treatment period of 7 days are given in Fig. No. 1 and 2 and the correlation analysis of parameters studied in Table No.1

Table No. 01: Correlation Analysis of different parameters observed after Treatment of Al_2O_3 to *Vigna radiata. L* seedlings

Parameter	Correlation Coefficient (r- Value)	d.f	P level	Statistical Significance
Concentration of Al_2O_3 Vs Chlorophyll-a	-0.939	5	0.01	Statistically Significant
Concentration of Al_2O_3 Vs Chlorophyll-b	-0.945	5	0.01	Statistically Significant
Concentration of Al_2O_3 Vs Total Chlorophyll	-0.941	5	0.01	Statistically Significant
Concentration of Al_2O_3Vs Carotenoid	-0.961	5	0.001	Highly Significant
Concentration of Al_2O_3 Vs Phaeophytin	-0.967	5	0.001	Highly Significant





The changes in Root length and Shoot length of 7 days old seedlings showed a gradual decline with the increase in Aluminium oxide (Al_2O_3) concentration (Fig. No.1) and the lowest was 66.3 %, and 37.6 % of control in root and shoot and the highest being 119.2 % , and 99.6 % of control in root and shoot respectively.

The changes in Pigments like Chlorophyll a, Chlorophyll b, Total Chlorophyll, Carotenoid and Phaeophytin showed also a decline trend with the increase in Aluminium oxide (Al_2O_3) concentration (Fig.No.2). There was high level of statistical correlation in case of Carotenoid and Phaeophytin concentration (Table No.-1)

Discussion

The common responses of shoots to Al include: cellular and ultra structural changes in leaves, increased rates of diffusion resistance, reduction of stomatal aperture, decreased Photosynthetic activity leading to chlorosis and necrosis of leaves, total decrease in leaf number and size, and a decrease in shoot bio-mass (Thornton et al., 1986).

Inhibition of root and shoot growth is a visible symptom of Al toxicity. The earliest symptoms concern roots. Shoots in contrast to the situation observed for Mn toxicity are less affected (Chang et al., 1999). Root stunting is a consequence of Al-induced inhibition of root elongation.

Roots are usually stubby and brittle and root tips and lateral roots become thick and may turn brown (Mossor- Pietra- szewska et al., 1997). Such roots are in efficient in absorbing both nutrients and water. Young seedlings are more susceptible than older plants. Al apparently does not interfere with seed germination, but does impair the growth of new roots and seedling establishment (Nosko et al., 1988).Many trivalent cations are toxic to plants and, because A1 toxicity is largely restricted to acid conditions, it is generally assumed that A13' is the major phytotoxic species Some researchers have considered the interaction between A1 and the membranes of root cells (e.g. Grauer and Horst, 1992; Kinraide et al., 1992), and this approach makes sense because regardless of what is happening in the surrounding solution, it is this interaction that will ultimately determine the degree of stress.

The root apex (root cap, meristem, and elongation zone) accumulates more Al and attracts greater physical damage than the mature root tissues In general; many plant species are resistant or can be tolerant to certain amounts of metals. This is probably achieved through trapping of these metals with metal-binding proteins. Many of the biochemical effects of Al on plants is probably associated with the alteration of root membrane structure and function (Hechi-Buchholz and Foy, 1981)

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