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Studies on the Impact of Fluoride Toxicity on Seed Germination of Amaranthus Dubius

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Abstract

An assessment was taken to study the impact on seed germination of Amaranthus dubius (red spinach) under fluoride ion. High concentration of fluoride ion in water suppresses the seed germination.[1,2] 0, 1, 2, 5, 25 and 50 mg/L (ppm) sodium fluoride solutions were used for this experiment. Fluoride reduced the number of seeds to germinate. It was noted by measuring the germination during the experiment. 25 and 50 ppm fluoride solutions suppressed the Amaranthus dubius germination by 30% and 40% respectively.

Key words: *Germination, ppm, seed, fluoride, concentration*

1. INTRODUCTION

Fluoride is commonly found in the environment and its percentage availability in the Earth's crust is 0.077 by volume.[3] It is an extremely reactive element. It is not available in nature as free form.[4] It readily reacts with other elements to form compounds. It also forms compounds with noble gases. High fluoride content is reported in most of the water in the middle East, East and central Asia and Africa (above 1.5 mg/L), which is the result of leaching from fluorine rich minerals.[5,6]

Fluoride is often mentioned as one of the pollutants. Fluoride compounds create pollution in the environment. It is ranked fifth in the environmental poisons.[7] Fluoride presents in soil, water, air and plants. It is not considered as an essential element for the normal growth of plants.[8] The problem of environmental pollution with fluoride compounds has been noticed recently and is mainly related to industrial activity, production of fertilizers (super phosphates) and the emission of fluoride compounds into the atmosphere in the form of dust and gas from aluminium smelters.[9]

Fluoride is one of the most toxic elements for plants. Fluoride inhibits germination, causes ultra structure malformations, reduces photosynthetic capacities, alters membrane permeability, reduces productivity, decreases biomass and inflict other physiological and biochemical disorders in plants.[10] Moreover, Fluoride toxicity may have important consequences such as reduction in growth or yield. [11] Fluoride reduces agricultural harvests by up to 50 percent because most plants are highly sensitive to fluoride. Fluoride compounds have been shown to be highly toxic to cereals and spinaches. [12, 13]

The red spinach (*Amaranthus dubius*) is one of the most widely eaten spinach varieties. It also plays an important role in Tamil cuisine, native to the middle East and cultivated in many parts of the world today. It is also widely eaten in Africa. *Amaranthus dubius* is used in Siddha medicine at Tamilnadu. Spinach is given as an important food to postpartum women as it gives heat to the body. In addition, it gives strength and stamina to the body by relieving the body weight caused by childbirth.

The aim of the present study is to examine the impact of *Amaranthus dubius* for 10 days treatment with sodium fluoride (NaF), in concentrations of 0 (control), 1, 2, 5, 10, 25 and 50 mg/L on the germination percentage, root and stem length, vigor index, and translocation factor.

2. MATERIALS AND METHODS

The experiment was carried out in natural climates and soil bed condition with cultivars of Red Lettuce seeds of *Amaranthus dubius*. The seeds were collected from Agriculture department, Government of Tamilnadu, Tirunelveli. A stock solution of 1000 mg/L was prepared by dissolving NaF crystals in distilled water.

Seven pots were selected, each one has 4kg of soil and mixed uniformly with 0.5kg of cow dung, kept it for 3 days. The *Amaranthus dubius* seeds were wetted with distilled water for 2 hours and 20 seeds were sowing with adequate space between them in the soil of each pot. Control was watering with distilled water and others were watering with 1, 2, 5, 10, 25 and 50 mg/L sodium fluoride solution. 50ml distilled water and 50ml 1, 2, 5 , 10, 25, and 50 ppm sodium fluoride solution were used to watering at early morning every day for control and treated respectively. After 10 days the germination was completed and the experiment terminated. The observation of number of seeds germinated in control, 1, 2, 5, 10, 25 and 50 ppm NaF treated were recorded separately from third day.

2.1 Data Analysis

2.1.1. Germination percentage:

Germination percentage (G.P) was calculated using the formula framed by international seed testing association methods.[14]

$$\text{G. P.} = \frac{Number\ of\ normally\ \ germinated\ seeds}{Total\ number\ of\ seeds} \text{X } 100$$

2.1.2. Root and stem length:

Root length and stem length were measured with a ruler after 10 days.

2.1.3. Vigor index:

Vigor index was calculated for NaF treated by the following equation.[15]
Vigor Index = (Stem length + Root length) × Germination Percentage

Fig 1 a) Control (0 mg/L NaF) b) Treated (10 mg/L NaF)

2.1.4. Fluoride uptake and translocation factor:

The stems and roots of seedlings were separated and dissolved separately in 0.1 M per chloric acid. Water extractable fluoride from stems and roots of seedlings were determined by ion selective electrode. The translocation factor (TF) of F in this seedlings were calculated by the following equation.[16]

$TF=(C_{Stem}/C_{Root})$

Where C_{Stem}= concentration of fluoride in plant's stem (mg/kg) and

C_{Root} = concentration of fluoride in plant's root (mg/kg)

3. RESULTS AND DISCUSSION

The effects observed in 1, 2, 5, 10, 25 and 50 ppm sodium fluoride on seed germination, fluoride uptake, stemt length, root length and translocation factor of *Amaranthus dubius* are given in tables from 1-3, Fig 1 and chart-1.

Fluoride is not an important element for the growth of plants. Previous studies show that fluoride affects a wide range plant processes such as respiration, starch synthesis, cell wall formation and enzyme activities.[17] Fluoride toxicities were resulted from the uptake of large doses of fluoride compounds. The adverse effects depend upon the irritating properties and the amount of the fluoride that has been taken up.[18]

Table 1 shows that germination percentage was reduced as 95%, 90%, 80%, 70% and 60% with 2, 5, 10, 25 and 50 ppm sodium fluoride treatment over control respectively. These findings are similar to observation in germination of *Cicer arietinum L* and *Hordeum vulgare L,*[19] in germination of *Raphanus sativus L* and *Abelmoschus esculentus L*[11] and in germination of *Triticum aestivum L.*[20]

Chart 1 shows that 100% germination in control (upper graph) while 60% germination in 50 ppm NaF treated (lower graph).

Fluoride reduced root elongation and stem elongation due to unbalanced nutrient uptake by seedlings.[21] Table 2 shows that uptake of fluoride was reduced the elongation of average root length as 34% with NaF treated over control. Average stem length decreased as 17% with NaF treated over control. Such a reduction in elongation of root length and stem length were reported in pulse crop *Cicer aritinum L.*[14]

Table 1. Percent germination and vigor index of *Amaranthus dubius* seeds

Analysing data	Control	1 ppm	2 ppm	5 ppm	10 ppm	25 ppm	50 ppm
Germination %	100	100	95	90	80	70	60
Vigor index (VI)	1030	950	922	828	640	791	390
VI % reduction	-	7.77	10.49	19.62	37.87	25.21	62.14

Table 2. Root and Stem lengths (cm) and percent reduction of *Amaranthus dubius* seedlings

Analysing data	Control	1 ppm	2 ppm	5 ppm	10 ppm	25 ppm	50 ppm
Root length (cm)	2.8	3	2.2	2.2	2	2.8	1
% reduction	-	+7.14	-21.42	-21.42	-28.57	0	-64.28
Stem length (cm)	7.5	6.5	7.5	7	6	8.5	5.5
% reduction	-	-13.33	0	-6.66	-20	+13.33	-26.66

Table 3 Concentration of fluoride in root and stem (mg/Kg) of *Amaranthus dubius* seedlings

Analysing data	Control	1 ppm	2 ppm	5 ppm	10 ppm	25 ppm	50 ppm
Root (F mg/Kg)	NA	4.141	4.918	5.516	6.476	8.826	11.206
Stem (F mg/Kg)	NA	2.031	2.482	3.344	4.139	6.124	8.568
Translocation factor	-	0.4904	0.5046	0.6062	0.6391	0.6915	0.7645

NA – Not applicable

Table 3 shows that the fluoride uptake in the *Amaranthus dubius* increased with increasing NaF concentrations. In root part it ranges from 4.141 mg/kg and stem part it ranges from 2.031 mg/kg. Translocation Factor (TF) is little high (0.4904) for *Amaranthus dubius* indicating that the stem tissues have less capability to hold F. Similar effect was also reported in *Abelmoschus esculentus.*[16]

The difference in uptake of fluoride by the plants between light and dark conditions was reported. Such a study has been reported in *Acacia georqinae* to determine the concentration of fluoroacetate.[14] It is 18 ppm in the roots and 9 ppm in the stem parts after 5 days. Larger fluoride was present generally in the root parts. More amounts of fluoride were taken up by the roots when higher the concentration of fluoride dosage 150 to 250 ppm.

Table 1 shows that vigor index was decreased 62.14%, 25.21%, 37.87%, 19.62%, 10.49% and 7.77% with 50, 25, 10, 5, 2 and 1 ppm concentration of fluoride treatment over control respectively. Similar reduction in vigor index has also been reported in *Triticumaestivum.*[1]

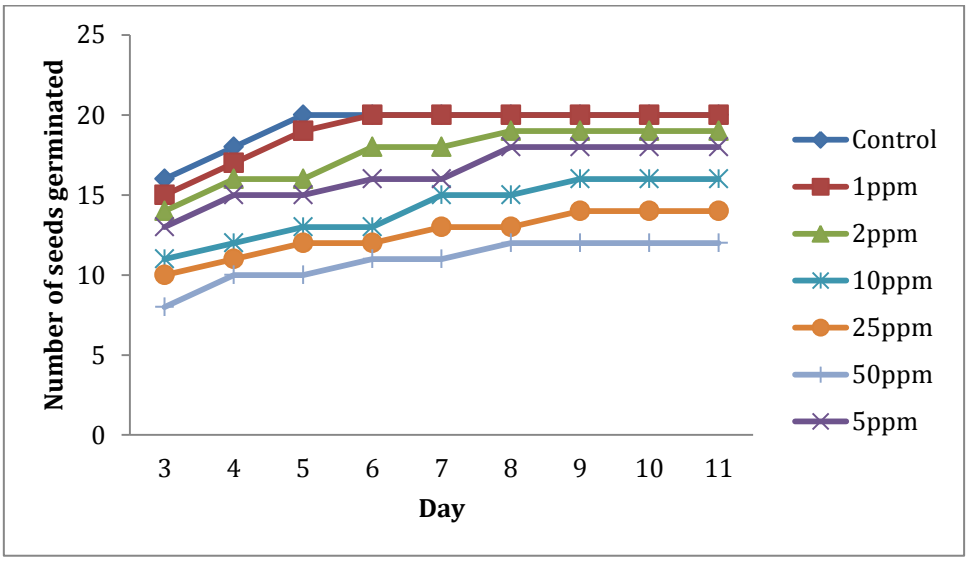

Chart - 1 Shows number of *Amaranthus dubius* seeds germinated

In solutions of 1, 2, 5, 10, 25 and 50 ppm sodium fluoride was found to cause inhibition of seed germination. Fluoride uptake reduced the growth and yield of plants. Varieties of plants of a species shown difference in fluoride uptake, growth and its yield.[22] Seeds treated to solutions of hydrogen fluoride or sodium fluoride during germination shows inhibiting effects. Weight of fresh seedlings decreased with increasing fluoride concentration due to reduction of metabolic activity.[23] Fluoride acts as a metabolic inhibitor for germination.[24]

4 CONCLUSIONS

In the present study 1, 2, 5, 10, 25 and 50 ppm NaF concentrations adversely affects the seed germination and seedlings growth of *Amaranthus dubius*. Germination percentage and vigor index decreased from 100% to 60% was also reported. The root length, stem length and dry weight were also affected by increased NaF concentration. The fluoride accumulation in the plant parts is indicated by translocation factor. Fluoride accumulation is an additional stress and affects plants growth. This knowledge is very helpful for farmers to avoiding excessive usage of fluoride containing fertilizers and irrigation of crops with fluoride contaminated water to increase crop productivity.

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