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Research Article

An experimental study on effects of fluoridated water on *Abelmoschus esculentus var. Soh-198* (Lady Finger)

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Abstract

An experimental study of fluoride (F) accumulation in *Abelmoschus esculentus var. Soh-198* and its effect on the growth and crop yield was conducted in a pot experiment. Eight different concentrations of F in the water were used for irrigation ranging from 2 to 14 ppm with distilled water as the control. Potentiometric determinations of the F content in different parts of the plant were made 45, 60, and 120 days after sowing the seeds (first, second, and third harvest, respectively). At the third harvest the highest mean plant part concentrations of F were recorded with 14 ppm F in the irrigation water: 9.0638 mg/kg in the roots, 5.6896 mg/kg in shoot, 4.5348 mg/kg in leaf and 3.563 mg/kg in fruit.

More Information

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Introduction

Fluoride is abundant in the environment and exists only in combination with other elements as fluoride compounds, which are constituents of minerals in rock and soil. Fluoride is very electronegative, which means that it has a strong tendency to acquire a negative charge and forms fluoride ions in solution. Fluoride transport through biological membranes occurs primarily through the non-ionic diffusion of Hydrogen Fluoride. Classic studies with artificial lipid bilayers and pH electrodes indicated that Hydrogen Fluoride is a highly permeant solute with a permeability coefficient similar that of water. The small neutral molecule of Hydrogen fluoride seems to penetrate cell membranes much faster than the dissociated fluoride ion, resulting in a more pronounced intracellular intake [1]. Fluoride combines with calcium to form calcium ionospheres that easily permeabilize the cell membrane [2]. Inorganic complexes are formed between fluoride and metallic ions such as aluminum (Al) or beryllium (Be), these compounds are biologically effective having a potential role in physiological and toxicological processes. Metabolic, functional and structural damage caused by chronic fluorosis have been reported in many tissues. Considerable experimental work has been done on plants regarding their capacity to accumulate F. Plant uptake of F from solution culture is dependent on plant species and positively related to the ionic strength of the growth solution. When F is present both as an air and soil pollutant, the uptake from air (through stomata) is far more significant than from soil. Uptake of F by roots is a passive, diffusion process [3,4]. Once a threshold F ion activity in nutrient solution was reached, F concentrations in plants increased rapidly [5-8]. A number of factors influence the action of fluorides on vegetation and the uptake and accumulation of F by plants [9-12].

Considerable experimental work has been done on plants regarding their capacity to accumulate F. Plant uptake of F from solution culture is dependent on plant species and positively related to the ionic strength of the growth solution. In this study the aim is to observe the amount of F accumulation and its effect on crop plant, a pot experiment with lady finger (*Abelmoschus esculentus*) has been conducted.

Materials and methods

Abelmoschus esculentus VAR. SOH-198 was selected for experimental study becauseit is adequately tolerant for semi-arid reigon and its maturity period ordinarily ranges between 110 and 120 days. Earthen pots were filled with sandy loamy soil. Water fluoridated at 2 ppm, 4 ppm, 8 ppm, 10 ppm, 12 ppm, and 14 ppm F ion prepared from a 100-ppm F stock solution made from NaF was used for irrigation at regular intervals and in equal quantity with distilled water as the control. For each concentration, 3 pots were used, and 5 replicates of each treatment were made. To ensure germination, 10 seeds were sown in each pot equally spaced from each other. After emergence, 5 seedlings were selected to remain in each pot and allowed to grow. The experiment was conducted during Feb - May.

After 45, 60, and 120 days from the date of sowing, treatments of three pots from each group were terminated, and the plants were harvested and washed gently with water to remove soil particles adhering to them. The plant parts were separated and then oven dried for 24 hr at 80 ºC. For determination of the F content, samples of the different plant parts were powdered and digested with nitric acid, followed by neutralization with aqueous KOH and analysis for F by the potentiometric method with a F ion selective electrode.

Samples were dried in an oven at 80 ºC for 48 hr and ground (< 1.0 mm) in a stainless steel mill. For each species a 2-g powdered sample was heating in an oven at 550 ºC until white ashes were formed. After extraction of the ash sample into NaOH solution, F concentrations were determined potentiometrically using a fluoride-specific ion electrode and a reference electrode. For measurement of total F (complexed and free) in solution, the NaOH extract was acidified with acetic acid glacial to pH 5.3 and mixed 1:1 with TISAB buffer. The TISAB buffer contained 57 mL acetic acid, 58 g NaCl and 4g CDTA per litre, adjusted to pH 5.2 with 6 M NaOH and diluted to 1 L with distilled water.

Results

In this study, accumulation of F in *Abelmoschus esculentus VAR. SOH-198* varied in the roots, shoots, leaves, and fruit, showing a uniform trend with increasing concentration of F in the irrigation water shown in tables 1-3.

Table 1: F concentration (mg/kg) in three plant parts of at the first harvest pre flowering stage 45 days after sowing the seeds.

Sr. N.	Treatment level	Root	Shoot	Leaf
1.	Control	0.3714 ± 0.113	0.2096 ± 0.061	0.0718 ± 0.045
2.	2 PPM	0.5662 ± 0.1145	0.3742 ± 0.0643	0.1176 ± 0.0510
3.	4 PPM	1.3222 ± 0.2739	1.032 ± 0.0379	0.6788 ± 0.1167
4.	6 PPM	2.1428 ± 0.2400	1.4084 ± 0.2558	0.8712 ± 0.0975
5.	8 PPM	2.6322 ± 0.3400	1.8626 ± 0.0784	1.0116 ± 0.0549
6.	10 PPM	3.1174 ± 0.2002	1.936 ± 0.0503	1.247 ± 0.1550
7.	12 PPM	3.6094 ± 0.0750	2.1546 ± 0.3149	1.6192 ± 0.1003
8.	14 PPM	4.2502 ± 0.2737	2.4024 ± 0.4081	1.903 ± 0.0720

Table 2: F concentration (mg/kg) in three plant parts of at the second harvest flowering stage 60 days after sowing the seeds.(± Std. deviation)

Sr. N.	Treatment level	Root	Shoot	Leaf
1.	Control	0.5982 ± 0.1779	0.4508 ± 0.0794	0.1396 ± 0.0609
2.	2 PPM	1.209 ± 0.3725	0.7476 ± 0.1803	0.3334 ± 0.0773
3.	4 PPM	1.921 ± 0.0635	1.4724 ± 0.0972	1.087 ± 0.008
4.	6 PPM	2.5582 ± 0.2476	1.8314 ± 0.0793	1.2726 ± 0.1070
5.	8 PPM	3.4628 ± 0.0695	2.3544 ± 0.1263	1.5552 ± 0.1125
6.	10 PPM	4.0062 ± 0.1403	2.8206 ± 0.1184	1.8848 ± 0.0639
7.	12 PPM	4.6942 ± 0.1403	3.344 ± 0.0811	2.0722 ± 0.0152
8.	14 PPM	5.3476 ± 0.2540	3.8062 ± 0.1285	2.2764 ± 0.0994

Table 3: F concentration (mg/kg) in four plant parts of at the third harvest post flowering stage 120 days after sowing the seeds

Sr. N.	Treatment level	Root	Shoot	Leaf	Fruit
1.	Control	0.6398 ± 0.1737	0.5364 ± 0.0393	0.2412 ± 0.0205	0.0658 ± 0.0443
2.	2 PPM	1.9372 ± 0.0844	1.3946 ± 0.2640	0.7588 ± 0.1299	0.3394 ± 0.1137
3.	4 PPM	2.6262 ± 0.1482	1.7854 ± 0.0867	1.3366 ± 0.0923	0.9432 ± 0.1124
4.	6 PPM	3.7766 ± 0.5341	2.4692 ± 0.0982	1.917 ± 0.1429	1.6686 ± 0.1787
5.	8 PPM	4.826 ± 0.3691	3.0492 ± 0.1778	2.132 ± 0.0500	1.988 ± 0.1050
6.	10 PPM	5.579 ± 0.0913	3.969 ± 0.2492	2.4152 ± 0.0960	2.2992 ± 0.0712
7.	12 PPM	6.9698 ± 0.5099	4.5296 ± 0.0678	3.2476 ± 0.5000	2.9558 ± 0.2661
8.	14 PPM	9.0638 ± 0.4265	5.6896 ± 0.6169	4.5348 ± 0.3437	3.563 ± 0.4927

In the present study Fluoride uptake in irrigation water by *Abelmoschus esculentus* (ladyfinger), showed that the roots accumulated most of the F supplied through the irrigation water, while the fruit accumulated least. In soil culture, the accumulation of F in the different plant parts followed the trend as root > leaves > fruit > shoot. In this experimental study signs of inorganic F phytotoxicity (fluorosis), such as chlorosis, necrosis and decreased growth rates, were most likely to occur in the young, expanding tissues of broadleaf plants and elongating needles of conifers. Earlier workers [13,14] also reported the similar trend (Figures 1,2).

Figure 1: Effect of fluoridated water on plant growth.

Figure 2: Effect of fluoridated water on fruit.

Conclusion

It is concluded that crop grown with fluoridated water retains fluoride in different plant parts in different quantity. In this study it was observed that fruits of *Abelmoschus esculentus* Var. SOH-198 also accumulated fluoride however quantity is less than fluoride accumulated by roots.

From the above study, in order to reduce the risk of human exposure to fluoride, the use of F contaminated irrigation water, especially for crops that tend to accumulate fluoride, should be reduced as much as possible. It is therefore very important, if possible, not to irrigated crops with fluoride contaminated irrigation water.

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