BIOACCUMULATION OF FLUORIDE IN DIFFERENT PLANT PARTS OF *HORDEUM VULGARE* (BARLEY) VAR. RD-2683 FROM IRRIGATION WATER

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SUMMARY: **An investigation of fluoride (F) accumulation in *Hordeum vulgare* (barley) var. RD-2683 and its effect on the growth and crop yield was conducted in a pot experiment. Six different concentrations of F in the water were used for irrigation ranging from 4 to 20 ppm with distilled water as the control. Potentiometric determinations of the F content in different parts of the plant were made 45, 90, and 135 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 20 ppm F in the irrigation water: 17.36 μg/g in the roots, 13.06 μg/g in the shoots, 11.74 μg/g in the leaves, and 14.44 μg/g in the crop (grain).**

Keywords: Fluoride in barley; Fluoride in plant parts; *Hordeum vulgare*.

INTRODUCTION

Even at fairly low ambient concentrations, fluoride (F) can cause a number of physiological and biochemical changes in plants without visible signs of injury. However, continuous use of high F water adversely affects crop growth. Phosphatic fertilizers, especially superphosphates, are the most important source of F in agriculture. High levels of F inhibit germination, cause ultrastructure malformations, reduce photosynthetic capacities, alter membrane permeability, reduce productivity, decrease biomass, and inflict other physiological and biochemical disorders in plants. In short, F can modify or disrupt metabolic processes and cause foliar lesions in plants.

In monocotyledons, the initial symptom is chlorosis at the tips and margins of elongated leaves. In dicotyledonous species, the leaves show chlorosis at the tip that expands progressively to the margins and midrib regions. More resistant species tend to accumulate more F from a given amount than susceptible ones.[1,2] Irrigation water can be an especially important source of F, and its uptake by plant roots grown in sand has been demonstrated, although much of the F remained within the roots.[3]

Although most F accumulation in the human body occurs through F-contaminated drinking water, substantial amounts of F can also be incorporated through grain crops and vegetables cultivated with F-contaminated irrigation water.[4,5] Here, in order to observe the amount of F accumulation and its effect on a grain crop, a pot experiment with barley was conducted.

MATERIALS AND METHODS

Hordeum vulgare (barley) var. RD-2683 was selected for experimental study. Its maturity period ordinarily ranges between 129 and 136 days. Earthen pots were

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filled with sandy loamy soil with cow dung as manure. Water fluoridated at 4 ppm, 8 ppm, 12 ppm, 15 ppm, 18 ppm, and 20 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, 9 pots were used, and 3 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 winter season. The temperature at the time of sowing were 28.6ºC (maximum) and 13.2ºC (minimum) recorded.

After 45, 90, and 135 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 80ºC. 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.

RESULTS

In this study, accumulation of F in *Hordeum vulgare* (barley) var. RD-2683 varied in the roots, shoots, leaves, and grain, showing a monotonic trend with increasing concentration of F in the irrigation water. Overall, the F levels were highest in the roots, next highest in the grain, and lowest in either the shoots or leaves.

As seen in Table 1, the accumulation of F at the first harvest was highest in the roots and lower in the shoots and leaves.

Table 1. Mean F concentration (μg/g) in three plant parts of *Hordeum vulgare* var. RD-2683 at the first harvest 45 days after sowing the seeds.

Parameter	F concentration in the irrigation water						
	Control	4 ppm	8 ppm	12 ppm	15 ppm	18 ppm	20 ppm
F in roots (μg/g)	0.0	1.10	1.66	2.52	3.02	3.92	5.16
F in shoots (μg/g)	0.0	1.02	1.32	2.14	2.32	3.42	4.34
F in leaves (μg/g)	0.0	0.80	0.82	1.44	1.66	2.56	4.84

At the second harvest (Table 2), F levels were also highest in the roots with F in the grain crop second and in decreasing order in the shoots and leaves except for 12 and 18 ppm F in the irrigation water.

Table 2. Mean F concentration (μg/g) in four different plant parts of *Hordeum vulgare* var. RD-2683 at the second harvest 90 days after sowing the seeds.

Parameter	F concentration in the irrigation water						
	Control	4 ppm	8 ppm	12 ppm	15 ppm	18 ppm	20 ppm
F in roots (μg/g)	0.0	3.02	4.84	5.88	6.54	7.64	8.08
F in shoots (μg/g)	0.0	1.98	2.76	2.52	4.84	5.48	6.96
F in leaves (μg/g)	0.0	1.88	2.14	3.42	4.34	6.32	6.54
F in crop ear (μg/g)	0.0	2.88	3.84	5.82	5.30	6.96	7.36

After the third harvest (Table 3), F accumulation was further increased in the same overall patterns except for 12 ppm F in the irrigation water.

Table 3. Mean F concentration (μg/g) in four different plant parts of *Hordeum vulgare* var. RD-2683 at the third harvest 135 days after sowing the seeds.

Parameter	F concentration in the irrigation water						
	Control	4 ppm	8 ppm	12 ppm	15 ppm	18 ppm	20 ppm
F in roots (μg/g)	0.24	4.66	6.54	8.96	10.46	11.34	17.36
F in shoots (μg/g)	0.0	2.76	4.48	5.66	7.88	8.92	13.06
F in leaves (μg/g)	0.0	2.56	3.50	6.82	6.70	8.08	11.74
F in crop ear (μg/g)	0.0	3.70	5.48	7.80	10.10	9.24	14.44

DISCUSSION

Owing to its relatively low mobility, F accumulated more in the plant roots in this study than in other plant parts. Similar findings have been reported by others.[6,7] In addition, F in mesophyll cells disturbs mineral metabolism, reduces chlorophyll pigments, and alters other morphological and physiological parameters such as height, number of leaves, biomass productivity, fruiting, and yield of the plant.[8] F affects photosynthesis by acting on membranes and stromal enzymes associated with carbon dioxide fixation.[9] In the food chain, F is transmitted from vegetation to herbivores and hence to carnivores.[10]

Here high concentrations of F in the irrigation water caused necrosis and chlorosis of leaves, reduction in growth of root and shoots, and ultimately reduced the yield of *Hordeum vulgare* var RD 2683. These observations are similar to those of other workers for other plants.[9,11-14] In the present study irrigation with high F water resulted in the accumulation of large amounts of F in the edible plant parts that are of considerable relevance to herbivore animals and humans. Although these environmental effects of F vary with different plant species, the findings presented here obviously have important implications for the successful management of agricultural operations.

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