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Phytotoxicity of Fluoride on a Wheat Variety (*Triticum aestivum* var. Raj. 4083) and its Bioaccumulation at the Reproductive Phase

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Abstract : The objective of the present study was to study the effects of different concentrations of NaF on different morphological characters, yield and its bioaccumulation in wheat variety (*Triticum aestivum* var. Raj. 4083). In a pot experiment, a wheat variety was irrigated with 4 – 16 mg/L NaF (4, 8, 12, 16, and 20 mg/L). The experiments were carried out for the entire life cycle of 120 days of this wheat variety. Plants were harvested after 120 days of sowing of seeds. There were significant changes in morphological characters and yield attributes in plants treated with 16 and 20 mg/L NaF. In plants treated with 20mg/L, significant reductions in shoot length (by 25.16%), root length (by 32.14%), number of leaves (by 42.40%), leaf area (by 19.50%) and grain yield (by 16.26%) were observed. Bioaccumulation studies of fluoride in plant parts revealed maximum accumulation in roots (4.24µg/g) and minimum in leaves (1.45µg/g) in plants treated with 20mg/L NaF. Results of the study showed that use of groundwater containing high fluoride content for irrigating wheat plants may be detrimental to its growth and yield.

Key words : Bioaccumulation, Groundwater, Morphological characters, Yield attributes.

Introduction

Many plants are sensitive to fluoride. Some species such as Gladiolus and Freesia are extremely sensitive to concentration <20µgFg^{-1} (Jacobson *et al.,* 1966; Istas and Alaerts, 1974). Certain physiological processes are known to be markedly affected by fluoride including plant growth, chlorosis, leaf tip burn and leaf necrosis (Miller *et al*., 1999; Elloumi *et al*., 2005). Fluoride is absorbed by plant roots (Kamaluddin and Zwiazek, 2003) and is then transported *via* xylematic flow to the transpiratory and storage organs. Bioaccumulation of fluoride in different plant parts varies depending on its transfer from soil solution to roots and translocation from root to shoot.

Tonk district of Rajasthan is one of the fluorosis endemic areas with high fluoride concentrations in the aquifers and soil. As majority of water for drinking and irrigation in this semi-arid region comes from aquifers, such high levels of exposure to fluoride are of great concern. In major regions of Rajasthan lying in semi-arid zones, wheat is cultivated with fluoride containing groundwater due to erratic rainfall. In the present study, therefore, we have investigated the effects of various increased concentrations of fluoride on morphological characters, yield and its bioaccumulation in wheat plants, after 120 days of sowing of seeds.

Materials and Methods

Plant Material, Growth Conditions and Fluoride Treatments

The experiments were conducted in the ecological garden of Department of Botany, University of Rajasthan, Jaipur from November, 2008 to March, 2009 during winter season. The mean ambient temperature during experimental study was 20^{0}C. Certified seeds of wheat (*Triticum aestivum* var. Raj. 4083) were procured from Agricultural Research Station, Durgapura, Jaipur. This variety was proposed for the Peninsular Zone (PZ) and has higher yield potential, disease resistance, desirable quality parameters and wider adaptability which would be helpful for enhancing the yield levels in Peninsular Zone of India.

Wheat plants were raised from seeds in the earthen pots filled with sandy-loamy soil and vermiform compost in the 1:1 ratio. 10 seeds were sown in each pot and then thinned down to five plants per pot after 15 days of germination. In the experiment, 3 replicates of each pot set *viz*. control 4mg/L, 8mg/L, 12mg/L, 16mg/L and 20mg/L were taken. The plants were watered with the respective concentration of NaF thrice a week throughout the experimental period (5 November 2008 to 5 March 2009).

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Stock solution of 100 mg/L NaF concentration was prepared by dissolving 0.221g of NaF in 1000ml of water. Serial dilution of stock solution was done to get the desired concentration.

Study of Morphological Characters and Yield Attributes

For the study of morphological characters, plants were harvested for each replicate after 120 days of sowing. The harvested plants were washed gently with water to remove adhering particles. Then plants were studied for various morphological characters and yield attributes.

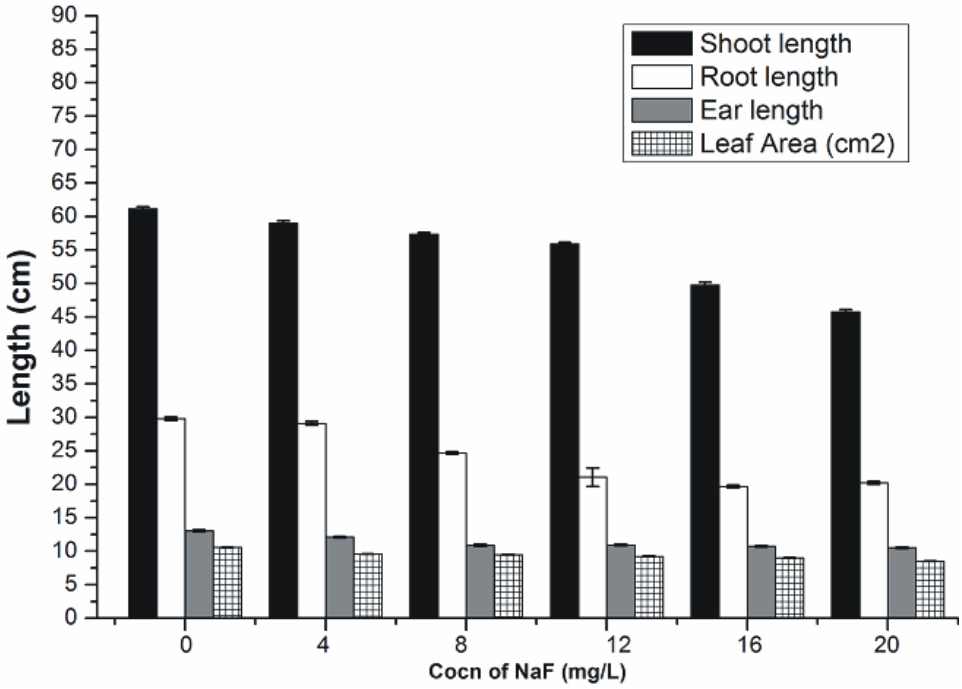
Determination of Bioaccumulation of Fluoride in Various Plant Parts

For the bioaccumulation study and determination of fluorine contents, all the plant parts were separately packed and oven dried for 24 hours at 80^0C. Then, the samples were powdered and digested with nitric aid, followed by neutralization with aqueous KOH and analysis for fluoride was done by potentiometric method with a fluoride ion selective electrode.

Results and Discussion

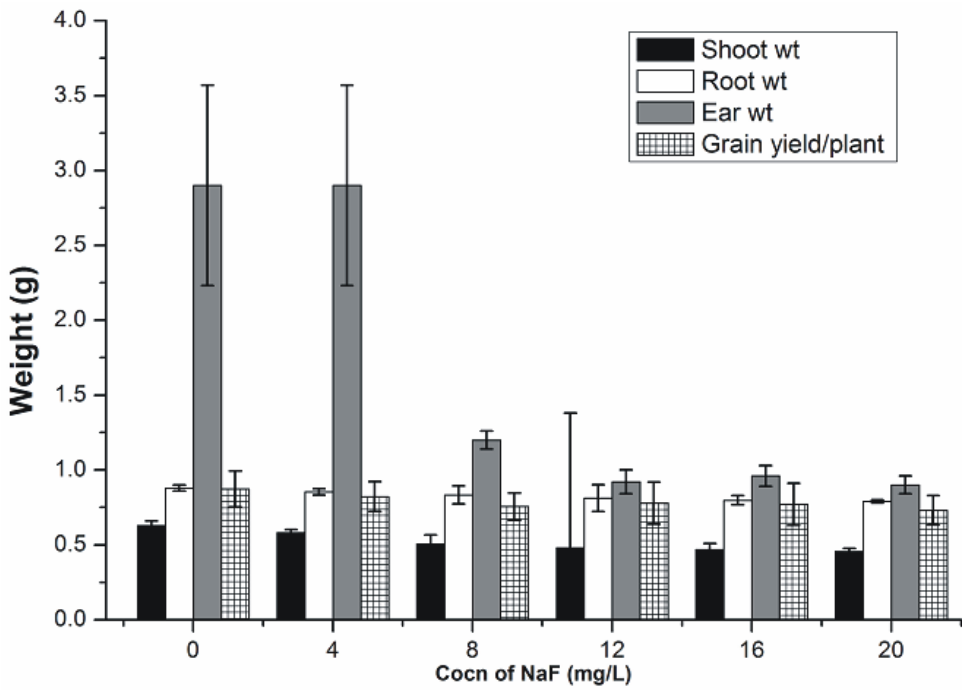
The results for the effects of increased fluoride concentrations on root length shoot length, ear length and leaf areas of wheat plants are shown in figure 1. With increased concentrations of fluoride, phytotoxicity was observed on both, root and shoot length (Figure 1). Compared to the control sets, there was 25.16% reduction in shoot length and 32.14% reduction in root length of NaF treated plants. Previously, the effects of various concentrations of fluoride (0.0001M, 0.01M and 0.2M) on root and shoot length of wheat, gram, mustard and tomato were studied by Pant *et al.* (2008). These workers find that at 0.02 M NaF, significant reduction in root and shoot length occurred in all the seedlings except the roots of tomato seedlings. Similarly, there was decrease in leaf area and leaf weight with increasing fluoride concentrations (Figure 1). Murray and Wilson (1988) exposed *Ecalyptus spp*. to fluoride concentration of 0.38 µg F/M^3 for 90 days in an open-top chambers. Fluoride significantly reduced the leaf surface area and weight of the mature and immature leaves.

Maclean and Schneider (1981) found a significant reduction by 20% in the mean dry weight of wheat plants exposed to 0.9µgF/M^3 for 4 days. In our experiment also, phytotoxicity was observed in terms of reduced dry weights of root, shoot, ear and grain yields per plants. In comparison to control set, shoot weight was reduced by 7.77% (0.581g) at 4mg/L, 19.52% (0.507g) at 8mg/



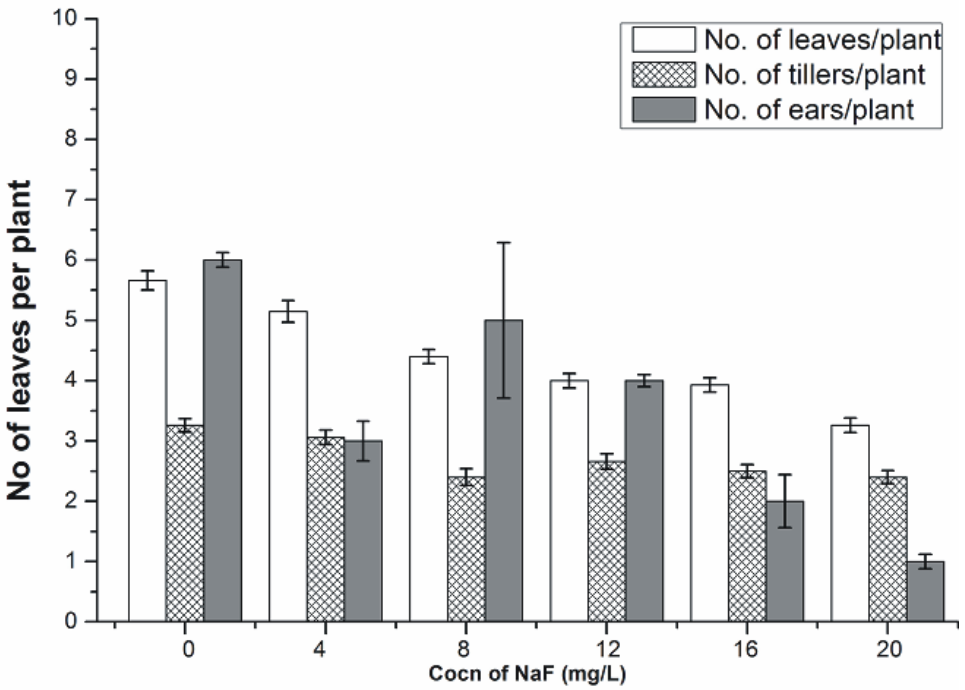
All values are mean + S.D of three replicates. Values are in cm.

Fig. 1: Effect of NaF on morphological characters and growth (shoot length, root length, ear length and leaf are) of Triticum aestivum var. Raj. 4083 after 120 days of sowing.



All values are mean + S.D of three replicates. Values are in g.

Fig. 2: Effect of NaF on morphological characters and growth (shoot weight, root weight, ear weight and grain yield/ plant) of *Triticum aestivum* var. Raj. 4083 after 120 days of sowing.



All values are mean + S.D of three replicates.

Fig. 3: Effect of NaF on morphological characters and growth (No of leaves/plant, No of tillers/plant and No of ears) of *Triticum aestivum* var. Raj. 4083 after 120 days of sowing.

Table 1: Mean Fluoride (F^-) Concentration (µg/g) in plant parts of Triticum aestivum var. Raj. 4083 at harvest after 120 days of sowing of seeds.

Parameter	F^- concentration in the irrigation water					
	Control	4 mg/L	8 mg/L	12 mg/L	16 mg/L	20 mg/L
F^- roots in (µg/g)	0	2.24 ± 0.12	2.62 ± 0.11	3.33 ± 0.09	3.78 ± 0.09	4.24 ± 0.08
F^- shoots in (µg/g)	0	0.86 ± 0.14	0.92 ± 0.12	1.54 ± 0.12	1.92 ± 0.13	2.12 ± 0.14
F^- in leaves(µg/g)	0	0.45 ± 0.09	0.66 ± 0.08	0.90 ± 0.08	1.25 ± 0.09	1.45 ± 0.09
F^- in grains (µg/g)	0	0.92 ± 0.12	1.31 ± 0.16	1.74 ± 0.14	2.43 ± 0.14	2.90 ± 0.16

L, 23.80% (0.480g) at 12mg/L, 25.71% (0.468g) and 27.61% (0.456g) at 20mg/L NaF concentration. Root dry weight was also reduced with increasing concentration of fluoride (Figure 2). It was found to decrease by 10.22% (0.790g) in 20mg/L NaF treated plants as compared to plants control (0.880g). The grain yield also showed a decline with increasing NaF concentration. The reduction was by 11.68% (0.771g/plant) and 16.26% (0.731g/plant) in 16mg/L and 20mg/L NaF treated plants respectively as compared to control (0.873g/plant) (Figure 2).

Figure 3 shows the results for effects of increased concentrations of NaF on number of leaves, tillers and ears per plants. In plants treated with 20mg/L NaF, there was 42.40% (3.26) decrease in number of leaves/plant. At the time of harvest, leaves dried and began to shed off. But aging and senescence was faster in fluoride treated plants compared to control.

Table 1 shows the bioaccumulation of fluoride in different parts of wheat plant at various concentrations of NaF. Bioaccumulation of fluoride was highest in roots and lowest in leaves. In 20 mg/L NaF treated plants, mean fluoride content in the root and shoot was 4.24 µg/g and 2.12µg/g respectively. In comparison to roots, leaves accumulated least fluoride which was 1.45µg/g. Owing to its low mobility, fluoride accumulated more in plant roots than in other plant parts. Similar findings have been reported by Gautam and Bhardwaj (2010). Bioaccumulation studies of fluoride in wheat grains showed an average fluoride content (2.90µg/g) in wheat grains. This study is significant since fluoride is a part of food chain in which it is transmitted from vegetation to herbivores and hence to the carnivores (Murray, 1981).

Results reported in this study show that fluoride treatment is detrimental to the growth and yield of wheat especially at higher concentrations (16mg/L and 20mg/L NaF concentrations). Bioaccumulation of fluoride in wheat grains creates secondary source of fluoride to human population resulting in food-borne fluorosis, primary source being water.

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