EFFECTS OF SOIL FLUORIDE ON THE GROWTH AND QUALITY OF TWO TOMATO VARIETIES GROWN IN PESHAWAR, PAKISTAN

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SUMMARY: The current study was conducted to evaluate the effects of soil fluoride ions (F) on the growth and quality of two locally grown tomato varieties in the Peshawar valley, Pakistan. The experiment was carried out at the Horticulture Nursery, Department of Horticulture, University of Agriculture, Peshawar, during 2011–2012. The objective of the study was to identify, for the farmers living in the vicinity of the F-emitting brick kiln fields of Peshawar, which of two tomato cultivars was most resistant to F. The seedlings of two tomato *(Lycopercicum esculentum)* varieties, Roma and Chinar, were each grown in two pots for each of six different treatments (T) with various F concentrations (T_1=0, T_2=10, T_3=30, T_4=50, T_5=100, and T_6=200 mg F/L). The leaves of both varieties were analysed for the % of ash, % of moisture, and the contents of protein, fiber, and fat after harvesting, by using their respective methodologies. Significant differences were found between the two varieties for the contents of fiber and fat ($p \leq 0.05$) but not for the % of moisture, % of ash, and protein. It was concluded that Roma variety is more sensitive to a high soil F content in comparison to the Chinar variety. Therefore, we recommend that farmers in the vicinity of ceramic industries and brick kilns in Pakistan, where higher F concentrations may occur in the soil and atmosphere, should use the Chinar variety of tomato, rather than the Roma variety.

Keywords: Ash; Fats; Fiber; Fluoride; Moisture; Pakistan; Protein; Soil pollution; Tomato.

INTRODUCTION

Fluoride, is one of the most toxic compounds found in particulate and gaseous pollutants. It is harmful to vegetation by causing physical injury to plants which not only minimize the yield but also change the nutritional values. Fluorine is the most electronegative element and does not occur in an elemental state in nature. It has tendency to react with all other elements except oxygen and the noble gases.[1] Fluoride contamination in the water, air and soil may come from various industries including aluminium smelters, ceramic manufacturers, phosphate fertilizer factories, and brick kilns.[2] Fluoride negatively affects the process of respiration, the metabolism of amino acids and proteins, and photosynthesis by acting on the membranes and the stromal enzymes associated with carbon dioxide fixation and resulting in lowered chlorophyll concentrations.[3] Animals grazing on fluoride affected plants may develop fluorosis, characterized by damage to the musculoskeletal system including difficulty in mastication, softening of the teeth, painful gait, and lameness. Fluorosis occur in animals grazing in fields near brickworks, aluminum smelters, and phosphate fertilizer factories.[4]

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The current study was based on previous research on the effects of fluoride emissions from brick kilns on crops in the vicinity of Peshawar city which showed that the atmospheric HF concentration may be high enough to cause significant foliar injury and reduce crop yield.[5] It was found that fruit in orchards and other crops, including tomato, were sensitive to F pollution. Therefore, two local tomato varieties were selected to assess the effects of soil fluoride ion levels on the proximate composition of tomato, an important fruit in the region as well as being widely used around the world.

MATERIALS AND METHODS

The current study was carried out in the University of Agriculture, Peshawar, Pakistan, in order to investigate the negative effects of fluoride ion levels (F) on the nutritive qualities of tomato. Two tomato varieties (*Lycopercicum esculentum*), Roma and Chinar, were sown in 24 pots of the same size, with two pots for each of the two varieties for each of the following six various treatments (T) with varying F levels: T_1=0, T_2=10, T_3=30, T_4=50, T_5=100 and T_6=200 mg F/kg. Sodium fluoride (NaF) was used as the F source. The pots were filled with 7 kg of soil and the tomato seeds were sown directly in the pots. The position of the pots was changed randomly every week in order to provide uniform light and temperature conditions. The plants were watered with deionised water regularly until harvesting. After harvesting, the plant leaves were collected, ground, and put in bags for drying at 70ºC for 48 hr. The dried plants were then analyzed for their proximate composition i.e., contents of ash, moisture, crude protein, crude fat, and crude fiber, by the methods of the AOAC.[6]

Ash content: The ash content of the leaves of both tomato varieties was analyzed using the ash combustion method.[6]

Moisture content: The moisture content in the leaves of both tomato varieties was measured with oven drying methodology.[6]

Protein content: The protein content of the leaves of both tomato varieties was determined using the Kjeldhal method.[6]

Fat content: The fat content in the leaves of both tomato varieties was analyzed using Soxhlet’s methods.[6]

Fiber content: The fat content determination of the leaves included alkali and acid digestion to saponify the fatty acids and hydrolyze the proteins, respectively. The drying, weighing, and ignition was done after obtaining a residue consisting of mineral matter and fiber by using a muffle furnace. The weight lost on ignition revealed the sample’s crude fiber content.[6]

Statistical analysis: A randomized complete block (RCB) design was used for analysis. The data summary (means and standard errors) was carried out using Microsoft Excel (2007) and the statistical analysis was carried out using MSTAT-C.[7]

RESULTS

The ash content values of the Roma variety were significantly higher than the ash content values of the Chinar variety (Table 1). The different F treatments did not affect the ash contents of either variety. The plants treated with low levels of F contained relatively low moisture contents compared to the plants treated with higher F levels suggesting that fluoride does not have any significant effect on the moisture content. The fat content of the Chinar variety was significantly lower with soil F concentrations above 50 ppm. The fiber content was significantly reduced in the Roma variety with all the treatments but the Chinar variety was not affected significantly. The protein content of both varieties increased markedly with increases in the soil F. All the F-treated Roma variety plants showed a similar increase in protein while, in the Chinar variety, the protein levels continued to increase with increasing soil F levels.

Table 1. Ash, moisture, protein, fat, and fiber content of the Roma and Chinar varieties of tomato at different levels of fluoride ion in the soil (ppm or mg F/kg)

Roma Cv. (F ppm)	Ash (%)	Moisture (%)	Protein (%)	Fat (%)	Fiber (%)
Control	19±2.00	8.91±0.09	29.65±2.65	7.5±0.00	9.5±0.50
10 ppm	14.5±2.50	9±1.00	41±9.00	7±0.00	8.5±0.00
30 ppm	22±4.00	8.875±0.87	43±8.00	7.5±0.00	8±0.00
50 ppm	21±1.00	10±0.00	43.375±6.62	7.1±0.10	8.05±0.05
100 ppm	23.5±0.50	10.425±1.33	46±0.00	7.05±0.05	8±0.00
200 ppm	22±0.00	9±0.67	46.375±11.37	7±0.00	7±0.00
Chinar Cv. (F ppm)	**Ash (%)**	**Moisture (%)**	**Protein (%)**	**Fat (%)**	**Fiber (%)**
Control	20±0.00	8.91±0.50	28.875±0.87	9±0.00	7.15±0.05
10 ppm	21.75±4.25	9±0.13	32.37±0.00	8±0.00	6.25±0.25
30 ppm	18.5±0.50	8.875±0.33	34±1.00	7±0.00	6.9±0.10
50 ppm	21±5.00	10±0.12	32.035±0.28	6.5±0.00	6.75±0.25
100 ppm	20.5±0.50	10.425±0.50	40.5±0.50	6±0.00	6.4±0.10
200 ppm	17.5±3.50	9±0.74	50.75±3.50	6±0.00*	6±0.00*

Values are expressed as mean±SE of the measurements. Comparing the levels in the F-treated plants of the Roma and Chinar varieties *$p \leq 0.05$.

DISCUSSION

In the current study of the two tomato varieties given increased levels of soil F, significant differences were found between the varieties in the fat and fibre content but not in the ash, moisture, and protein levels. The Roma variety was more adversely affected than the Chinar variety. Previous work shows that F can adversely affect many aspects of cellular physiology and biochemistry.[8] The ash content was not significantly affected in either variety by F. The fiber content in the Roma variety was significantly reduced in a progressive manner as the F levels in the F treatments increased but no significant change in fibre content occurred in the Chinar variety. The protein levels increased in both varieties with F treatment without a significant difference in this being present between the two varieties.

This is consistent with previous studies showing increased protein levels with increased soil fluoride.[9] Increasing F concentrations resulted in an increase in the proline concentration in *Abies alba* leaves which contributed to an enhanced tolerance capacity under stress conditions.[10] Increased soil F concentrations have resulted in a significant increase in the amino acid content in *Helianthus annuus*.[11] A significant increase was found in the content of the amino acid proline content with NaF treatment in *Vigna radiata*.[12] The increase in protein content may be due to a synergistic effect of F with nitrogen as protein synthesis is directly related to the soil nitrogen concentration.[13] The nitrogen in the soil is taken up by the plants.

Different varieties of the same species may respond differently to F pollution due to variety of environmental conditions. In the current study, in terms of nutritional quality, it was found that the Roma variety is more sensitive to a high soil F content than the Chinar variety. Therefore, farmers in the vicinity of ceramic industries and brick kilns in Pakistan, where F concentrations can be high, should use the Chinar variety, rather than the Roma variety, to overcome the negative effects of F.

Similar studies should also be carried out for other pollutants, mainly ozone (O_3) and hydrogen fluoride (HF), emitted from brick kilns that can also damage crop growth and yield.[14-16]. The effects of air pollution on environmental diversification among vegetation is also important as there is need to identify resistant species of plants and crops species to secure future food security in South Asia.

REFERENCES

1 WHO. Fluorine and fluorides. Environmental Health Criteria 36. International Program on Chemical Safety. Geneva: World Health Organisation; 1984.
2 Wellburn A. Air pollution and climate change: the biological impact. New York: Longman Scientific and Technical;1994.
3 Garrec JP, Plebin R, Audin M. Effets du fluor sur les teneurs en sucres et en acides amines d'aiguilles de sapin *Abies alba* Mill [Effects of fluoride on the levels of sugars and acids amines of fir needles *Abies alba.* Mill] Environmental Pollution Series A Ecological and Biological 12/1981;26(4):281-95. DOI:10.1016/0143-1471(81)90050-7.
4 Patra RC, Dwivedi SK, Bhardwaj B, Swarup D. Industrial fluorosis in cattle and buffalo around Udaipur, India. Sci Total Environ 2000; 253(1-3):145-50.

5 Ahmad N, van den Berg LJ, Shah HU, Masood T, Büker P, Emberson L, Ashmore L. Hydrogen fluoride damage to vegetation from peri-urban brick kilns in Asia: a growing but unrecognized problem? Environ Pollut 2012;162:319-24.
6 AOAC. Official methods of analysis. 14th ed. Washington, DC: The Association of Official Analytical Chemists; 2003.
7 Steel RGD, Torrie JH. Principles and procedures of statistics: a biometrical approach. 2nd ed. New York: McGraw Hill Book Company; 1980.
8 Miller GW. The effects of fluoride on higher plants with special emphasis on early physiological and biochemical disorders. Fluoride 1993;26(1):3-22.
9 Sreedevi R, Damodharam T. Exterminate consequence of NaF on seed germination and some morphological changes of major pulse crop *Cicer aritinum* L. Cv. Anuradha (Bengal gram). Plant Science and Research 2013;3:38-41.
10 Saleh AAH, Abdel-Kader DZ. Metabolic responses of two *Helianthus annuus* cultivars to different fluoride concentration during germination and seedling growth stager. Egyptian Journal of Biology 2003;5:43-54.
11 Gadi RB, Pooja V, Ram A. Influence of NaF on seed germination, membrane stability and some bio-chemicals content in *Vigna* seedlings. Journal of Chemical, Biological and Physical sciences.Section B: Biological Sciences 2012; 2:1371-8.
12 Weinstein LH, AW Davison. Native plant species suitable as bioindicators and biomonitors for airborne fluoride. Environ Pollut 2003;125: 3-11.
13 Ahmad MN, van den Berg LJ, Shah HU, Wahid A, Khalid S, Büker P, et al. 3Effects of ozone on peri-urban vegetable crops in South Asia. Environ Pollut 2013;174:244-9.
14 Wahid A, Ahmad SS, Ahmad MN, Khaliq B, Nawaz M, Shah SQ, Shah RU. Assessing the effects of hydrogen fluoride on mango (*Mangifera indica* L.) in the vicinity of a brick kiln field of Southern Pakistan. Fluoride 2014;47(4):307-14.
15 Ahmad MN, Ahmad SS, Zia A, Iqbal MS, Shah HU, Mian AA, RU Shah RU (2014) Hydrogen fluoride effects on local mung bean and maize cereal crops from peri-urban brick kilns in South Asia. Fluoride 2014;47(4):315-9.
16 Ahmad SS, Murtaza R, Shabir R, Ahmad MN, Shah TA. Environmental diversification and spatial variations in riparian vegetation: a case study of Korang River, Islamabad. Pakistan Journal of Botany 2014;46(4):1203-10.