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Ameliorating effect of ascorbic acid on the content of minerals in *Eruca sativa* Mill. under different air pollutants

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Abstract: The experiment was conducted to study the effect of different air pollution (ozone O_3, sulfur dioxide SO_2, and nitrogen dioxide NO_2 gases) on *Eruca sativa* Mill. at three locations in Riyadh city, KSA. During the study, we found that the concentrations of gases were increasing gradually at the study sites. Ozone concentration and sulfur dioxide at the cement factory area site were 91 ppb and 29 ppb, respectively, as well as concentration of nitrogen dioxide was 29 ppb at the first industrial area and cement factory area. The present experiment showed that these three pollutants gases caused a significant effect on the concentration of some mineral elements. Interestingly, the plants treated with ascorbic acid showed maximum content of mineral nutrients phosphorus (P), potassium (K), nitrogen (N), cupper (Cu), iron (Fe), zinc (Zn) and manganese (Mn). The study aims to identify concentrations of ozone gas, sulfur dioxide and nitrogen dioxide in three different locations in Riyadh and determine its harmful effects on the concentration of some metal elements, and study the effect of ascorbic acid to reduce the adverse impact of these gases in *Eruca sativa* Mill.

Keywords: Ozone, Sulfur, Nitrogen Dioxide, Ascorbic Acid, *Eruca sativa*

1. Introduction

Toxic air pollutants such as ozone (O_3), sulfur dioxide (SO_2), nitrogen dioxide (NO_2) enter into the atmosphere at increasing rates due to the increasing population and industrialization. An increasing concentration of air pollutants limits the growth and developmental of agricultural crops. High concentration of air pollutants alters air quality and affects people, flora and funa (Govindaraju, Ganeshkumar, Muthukumaran & Visvanathan, 2012). Plants are generally more affected than animals by air pollution, as they constantly take up atmospheric gasses. Of all plant parts, the leaf is the most sensitive part to the air pollutants (Meerabai, Venkata Ramana, & Rasheed, 2012). Ozone enters into the plant through stomata where decompose in cell wall water and then interacts directly with the plasma membrane through decomposition process (Ozonolysis) or turns to the forms of oxygen active. These interactions change cellular components that may lead to the acceleration of senescence or cell death (Logan & Naidu, 2002).Mineral nutrients are essential for plants to complete their life cycle. Plant mineral nutrients constitute a major component of many metabolic active compounds such proteins, hormones, chlorophyll, vitamins and enzymes. Most studies about ozone effects on plant nutrition were on trees, so the available information on the response of trees to ozone effect, probably cannot be generalized to herbaceous plants, for which information is scarce (Fangmeier, De Temmerman, Black, Persson, & Vorne, 2002). There are few studies available on this subject. Response of plants to pollutants differs markedly, some are highly sensitive and others hardy and tolerant to pollutants (Singh & Rao 1983; Shannigrahi & Agrawal, 1996; Chaulya, Chakraborty, & Singh, 2001).

Ascorbic acid (ASA) is an important growth regulator that affects many physiologic processes (Hathout, 1995; Gonzlez, Steffen, & Lynch, 1998). It is well established that ascorbic acid plays a key role in photosynthesis as an enzyme cofactor (including synthesis of ethylene, gibberellins and anthocyanins) and in control of cell growth and cell expansion and in resistance to environmental stresses (Smirnoff & Wheeler, 2000).

In recent decades Riyadh has witnessed a big industrial development that had a negative impact on the environment. The increase in population, which exceeded four million, has significant impact on increasing the number of transportation and need for energy and various services, therefor increased fuel consumption and burne leading to excessive increase in the rates of emission of pollutants that have a negative impact on the plant.

Rocket *(E. sativa* Mill) is an annual herb belonging to the Brassicaceae family, its spicy hot flavor; rocket is very important crop and use in salads for flavor and in large variety of meals. According to D'Antuono, Elementi and Neri (2009) and Barillari et al. (2005), rocket contains a number of health promoting agents including carotenoids, vitamin C, fibers, flavonoids, and glucosinolates (GLs). The aim of our research was to measure the concentrations of ozone gas, sulfur dioxide and nitrogen dioxide at three different locations in Riyadh city and to determine its harmful effects on the concentration of some mineral elements in *E. sativa* Mill. and the role of ascorbic acid to reduce the impact of these gases.

2. Materials and Methods

2.1. Sites of Study

Three different sites were selected (King Saud University, the first industrial area and cement factory area) to study in Riyadh city. At the beginning of the experiment, seeds of *E. sativa* Mill. were sown outdoors in plastic pots 25 cm containing sandy loam soil and added a fungicide to prevent of fungus. Three pots were taken for each concentration. We maintained three plants in each pot throughout the experiment. When the plant was at the stage of 2-4 true leaves, pots were shifted to the study sites for study. Plants in the study sites were irrigated once every 15 days with following concentrations of ascorbic acid (zero, 50,100, 200, 300 and 400 mg/L).

2.2. Agriculture

Seeds of *Eruca sativa* Mill. were planted outdoors in plastic pots 20 cm in sandy loam soil sterile 1:1 added a fungicide to prevent of fungus, three pots was put for each concentration, each pot contains three seeds have washed and sown on May 10, 2011, and left even completed the initial leaves growth, then transferred to the study sites.

2.3. Treatment

Plants in the study sites were irrigated once every 15 days with following concentrations of ascorbic acid (zero, 50,100, 200, 300, 400 mg / L).

2.4. Measurements

The concentration of ozone, sulfur dioxide and nitrogen dioxide were recorded daily at the study sites using multi-gas analyzer (Gray Wolf, Sweden), and then calculated the average. Plant samples were taken from the leaves of *E. sativa* Mill. at the late vegetative growth before flowering stage. Estimation of phosphorus was done using (Spectrophotometer–LKB-4050) (Murphy & Riley, 1962). Potassium content was measured using Flame Photometer (Allen, 1989). Organic carbon was estimated according to Tandon (1993). Estimation of nitrogen was done using microkjeldahl (Jones, 1991). Elements (copper, iron, zinc, and manganese) were done using atomic absorption spectroscopy according to Stewart (1989).

2.5. Statistical Analysis

The experiment was Completely Randomized Design with three replicates.The data were analyzed statistically by analysis of variance according to Gomez and Gomez (1984). For the F-test, the error due to replicates was also determined. When the F-value was found to be significant at 5% level of probability, the least significant difference (LSD) was calculated.

3. Results

3.1. The Concentrations of Gases (Ozone, Sulfur Dioxide and Nitrogen Dioxide) at the Sites of Study

The results in Table (1) show that the concentration of gases was found different at these sites. We noted that the concentrations of (O_3, SO_2, and NO_2) at the site of the King Saud University were less than in the first industrial area, and cement factory area. Where O_3 concentration at the site of the King Saud University, the first industrial area and the cement factory area during the month of March was 60, 87 and 91 ppb respectively. The concentration of SO_2 at the site of the King Saud University, the first industrial area and the cement factory area during the month of March was recorded 12, 26 and 25 ppb respectively. In addition, the concentration of NO_2at the site of the King Saud University, the first industrial area and the cement factory area during the month of March was 11, 29 and 27 ppb.

3.2. Mineral Elements Content in Plants

The results in Table (2) reveal that the gases (O_3, SO_2, and NO_2) had a significant effect on mineral elements in *E. sativa* Mill grown at all sites. However, their effects were found different among the plants grown at three sites. In the present study we noticed a general trend that the content of mineral elements in plant grown at these sites increased with increasing treatments of ascorbic acid. The plants grown at the kind Saud University site showed maximum content of mineral nutrient in comparison to those plants grown at sites of the first industrial area and the cement factory area. Application of 400 mg/L of ascorbic acid exhibited 4.35, 3.85, 3.31 mg/L of phosphorus, and 0.92, 0.57, 0.47% of nitrogen, and 0.37, 0.31, 0.27 mg/L of manganese in plants grown at the site of King Saud University, the first industrial area and the cement factory area, respectively.

Table 1. *Average of monthly reading for ozone, sulphur dioxide and nitrogen dioxide at study sites*

Location	Months	Concentration Average (ppb)		
		O_3	SO_2	NO_2
King Saud Uni.	Jan.	55	10	12
	Feb.	54	8	14
	Mar.	60	12	11
First Industrial City	Jan.	72	24	26
	Feb.	79	28	24
	Mar.	87	26	29
Cement Factory	Jan.	78	27	24
	Feb.	83	29	29
	Mar.	91	25	27
Limit global air pollution (ppb) (CASTNET, 2004)		30-25	30	35

Table 2. *Effect of gases (ozone, sulphur dioxide, nitrogen dioxide and Ascorbic acid) on the content of mineral elements in E. sativa Mill.*

Location	Treatment		P (mg/L)	K (mg/L)	C (%)	N (%)	Cu (mg/L)	Fe (mg/L)	Zn (mg/L)	Mn (mg/L)
King Saud Uni.	ASA (mg/L)	0	3.55	153	27.49	0.45	0.12	4.03	0.33	0.23
		50	3.61	154	27.75	0.49	0.17	4.34	0.34	0.29
		100	3.95	156	28.69	0.55	0.22	4.73	0.35	0.33
		200	4.21	158	30.92	0.62	0.26	4.82	0.37	0.34
		300	4.32	161	31.07	0.78	0.28	5.13	0.42	0.35
		400	4.35	162	31.14	0.92	0.28	5.24	0.43	0.37
Cement Factory	ASA (mg/L)	0	2.25	148	25.23	0.32	0.09	3.54	0.30	0.20
		50	2.81	146	25.42	0.34	0.09	3.65	0.30	0.22
		100	3.11	150	25.66	0.41	0.13	4.03	0.31	0.25
		200	3.51	151	27.52	0.42	0.17	4.07	0.31	0.28
		300	3.62	153	27.22	0.51	0.19	4.54	0.32	0.28
		400	3.85	155	28.21	0.57	0.19	4.67	0.33	0.31
First Industrial City	ASA (mg/L)	0	1.44	146	23.43	0.30	0.07	3.01	0.28	0.16
		50	2.23	146	23.47	0.31	0.07	3.03	0.29	0.19
		100	2.54	148	24.61	0.35	0.8	3.43	0.30	0.21
		200	2.88	149	24.72	0.38	0.9	3.67	0.30	0.22
		300	3.12	150	24.74	0.42	0.9	3.98	0.31	0.22
		400	3.31	150	25.22	0.47	0.11	4.01	0.31	0.27
LSD at 0.05			0.445	3.32	0.028	0.028	0.030	0.030	0.033	0.029

4. Discussion

The results showed that ozone concentration in the three sites under the study exceeded from the allowable universally limit (25-30 ppb).The site of the King Saud University scored less concentration compared with other two sites (the first industrial area and the cement factory area).While the concentration of sulfur dioxide and nitrogen dioxide did not exceed from the allowable global limit of air pollution (CASTNET, 2004; Fenger, 2009). A difference in leaves content of some mineral elements in plants grown at these sites was found because of different concentration of O3 at three sites. Plants grown at the King Saud University site (less content of O3.Table1) showed maximum content of mineral elements as compared to the plants grown at the site of the first industrial area and the cement factory area (Table 1 and 2). Were evident in the study sites, the differences were statistically significant; low proportion of mineral elements in plant leaves in the first industrial area and a cement factory area compared with the plants at King Saud University site may be due to an increase ozone concentration. This result is consistent with the findings of Fangmeier, De Temmerman, Black, Persson and Vorne (2002) and Schier, McQuattie and Jensen (1990), which pointed out that exposure to high ozone leads to shifts or changes in the concentration of elements within the plant tissue.In the present study we found that application of ascorbic acid showed surprising effect on mineral elements content of plants grown in at these study sites. Application of ascorbic acid increased all mineral elements content in plants grown at all sites (Table 2). As we know that ascorbic acid is an important component of plants and its concentration reaches of over 20 mM in chloroplast and occurs in cell was. Therefore, the concentration of mineral elements in leaf increased may be due to antioxidative properties of ascorbic acid that efficiently scavenges toxic free radicals and other reactive oxygen species generated in cell due to zone (Arrigoni & Tullio, 2002; Smirnoff, 1996). Also, Foyer (1993) reported that ascorbic acid plays a role in the physiological processes in the plant, small concentrations of it regulates plant growth.

5. Conclusions

This investigation has demonstrated that the concentration of air pollutants (O_3, SO_2, and NO_2) in the study sites has increased, average concentration of ozone O_3 per month was higher than allowable limit, while concentration of SO_2, and NO_2 did not exceed globally limit allowable. The air pollutants in the study sites had a significant effect on the mineral content in the plants. The content of mineral elements increased with increasing concentration ascorbic acid.

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