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Impact of O_3, SO_2 and NO_2 on Carbohydrate Content Level in Bean Plant (*Phaseolus vulgaris* L.) Grown Under Ascorbic Acid at Various Sites of Riyadh, Kingdom of Saudi Arabia

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ABSTRACT: This study was conducted at three locations of Riyadh under varying pollution of ozone, sulfur dioxide and nitrogen dioxide gases. The bean seeds were grown in three pots under concentrations of ascorbic acid (zero, 100, 200, 300 mg/L). The results showed that the concentration of polluted air in the Riyadh was gradually increased during the study period, reaching concentration of ozone gas to 77 (ppb) at the urban area site, sulfur dioxide gas to 21 (ppb) at the site of the sub-urban area and the nitrogen dioxide gas to 22 (ppb) in a urban area. The results also showed that there was a significant effect of those pollutants on carbohydrate content, where the content of monosaccharides in beans leaves were ranging between 8.1 to 5.7 (mg/g) at the rural area and the urban area sites, respectively. The disaccharides content was ranging between 23.0 to 20.6 (mg/g) at rural area and urban area sites, respectively. The polysaccharides content was ranged between 38.8 (mg/g) at rural area and 33.7 (mg/g) in an urban area sites, respectively. The study also proved that ascorbic acid (ASA) had a positive role on the metabolism of carbohydrates and provides plant resistance to oxidizer ozone gas, which supports the proposed role of ascorbic acid in the removal of toxic free radical species, in addition to its ability to resist environmental stress factors.

KEYWORDS: Air Pollutants; Ascorbic Acid(ASA); Bean Plant and Carbohydrate Content.

INTRODUCTION

Ozone gas is an oxidizing gaseous air pollutant in the troposphere, which is formed in the air under the influence of the sun and lightning (Sandermann et al., 1998). Ozone enters in the plant through the stomata as it dissolves in the water and interacts with cell wall and then interacts directly with the plasma membrane through the process of decomposition (Ozonolysis) or turn to reactive active oxygen species that interacts with the plasma membrane and the amino acids in the target cell membrane proteins. These interactions change the cellular components may lead to accelerated aging or cell death (Logan and Naidu, 2002).

Ozone affects the metabolism of carbohydrates through its direct effect on the photosynthesis reactions and indirectly through its effect on the stomata delivery where it is noted that plants respond to ozone by closing the stomata to avoid the toxic ozone (Sanmartin et al., 2003). It affects the level of carbohydrates due to a reduction of photosynthesis and the mutation in the distribution of carbon (Drogoudi and Ashmore, 2002). Iglesias et al. (2006) found that the carbohydrates levels are low in plant leaves of *Citrus clementina* treated with ozone concentration of 47 ppb and 65 ppb, where sucrose was decreased by 23% and 52% in those leaves as compared with the plant leaves treated with coal-filtered air, as noted the decline in other plants such as beets and turnips (Kollner and Krause, 2003). The ascorbic acid (ASA) is considered as a growth regulator factor which affects on many physiological processes (Hathout, 1995). Gonzlez et al. *(*1998) noted that the depletion of ascorbic acid in the plant cells start the falling of leaves thus it was proved that ascorbic acid is effective in resisting stresses. Under low concentration of ascorbic acid in plants, they are very sensitive to ozone,

which emphasizes its role in resistance to oxidative stress (Veljovic-Jovanovic et al., 2001). The study of Conklin et al. (1996) proved the role of ascorbic acid in plant resistance to ozone gas oxidizer, which supports the proposed role of ascorbic acid in the removal of toxic oxygen species, in addition to its ability to resist environmental stress factors.

This study aims to quantify the concentrations of gaseous air pollutants at three different locations in the Riyadh and determine their effects on carbohydrates content level in the *Phaseolus vulgaris* plant and study the effect of ascorbic acid in reducing the adverse impact of these gases.

MATERIALS & METHODS

Study sites

Three sites belonging to Riyadh , *i.e.* rural area, the sub-urban area and urban area were selected for this study as a varying gaseous air pollutants at these places.

Experimental procedures

Cultivation of seeds

Three dry seeds of *P. vulgaris* were sown in plastic pots containing sterilized sandy: mud (1:1, v/v) soil treated with fungicide for the prevention of fungal growth. The pots were left until the completion of growth of primary leaves and then transferred in the open air of the study sites.

Ascorbic acid (ASA) treatments

ASA concentrations including 0, 100, 200 and 300 mg/L in H_2O were prepared, and the beans plants were treated with this solution as irrigation solution every 15 days at the study sites until the end of cultivation time of beans plants.

Measurements

Leaf samples were taken from the *P. vulgaris* at the end of vegetative growth and before the flowering stage of beans plant. The concentrations of ozone, sulfur dioxide and nitrogen dioxide were measured per day for each study site for the duration of cultivation time of beans plant, *i.e.* June, July and August months using a AEROQUAL Series Monitor with multi head. Monosaccharides, disaccharides and polysaccharides were determined according to method of Feteris (1965), Handel (1968) and Thayumanavan & Sadasivam (1984), respectively.

RESULTS

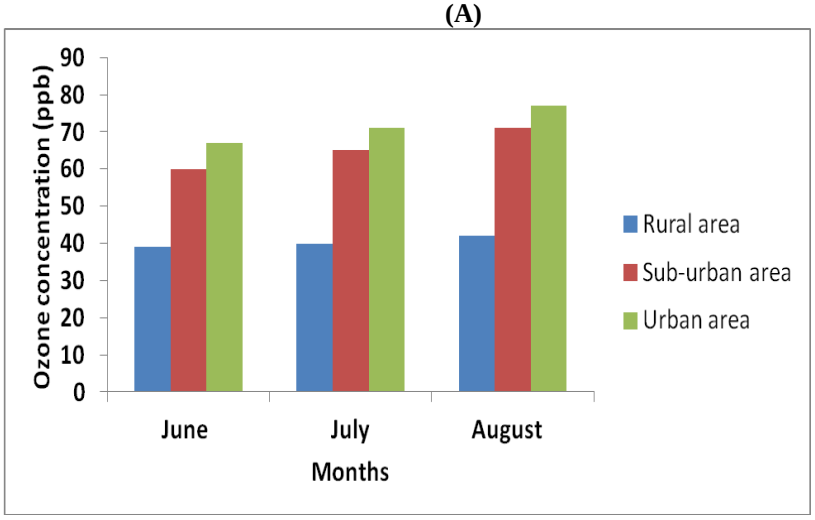
Measurements of concentrations of gaseous air pollutants at the study sites

Results shown in Table (1) and illustrated by Figure (2A, B and C) indicated that the concentrations of ozone, sulfur dioxide and nitrogen dioxide were increased at the study sites, where it was observed that the concentrations of ozone, sulfur dioxide and nitrogen dioxide at the rural area were less as compared with the sub-urban area and urban area. As the concentration of ozone at the site of rural area, the sub-urban area and urban area was 42, 71 and 77 ppb, during the month of August respectively (Figure 2; A). The concentration of sulfur dioxide at the site of rural area, the sub-urban area and urban area during the month of August was 7, 20 and 21 ppb, respectively (Figure 2; B).The results also showed that the concentration of nitrogen dioxide at the site of rural area, the sub-urban area and urban area was 9, 21 and 22 ppb, during the month of August was respectively (Figure 2C).

Table1. Average monthly reading of gaseous air pollutants (ozone, sulfur dioxide and nitrogen dioxide) at the study sites

Site	Month	Concentrations (ppb)		
		O_3	SO_2	NO_2
Rural Area	**June**	39	6	8
	July	40	6	9
	August	42	7	9
Sub-urban Area	**June**	60	18	19
	July	65	19	20
	August	71	20	21
Urban Area	**June**	67	18	19
	July	71	19	20
	August	77	21	22
Limit of global air pollution (ppb)		25-30	30	35

(A)



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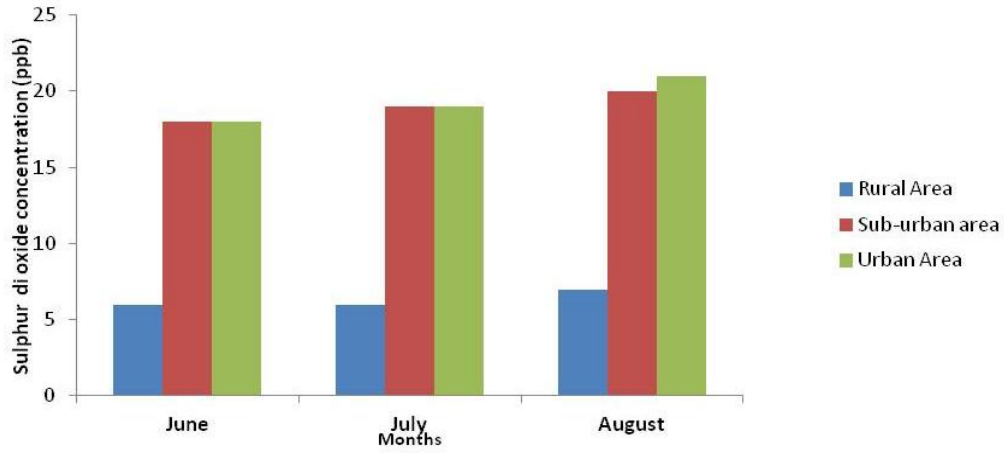

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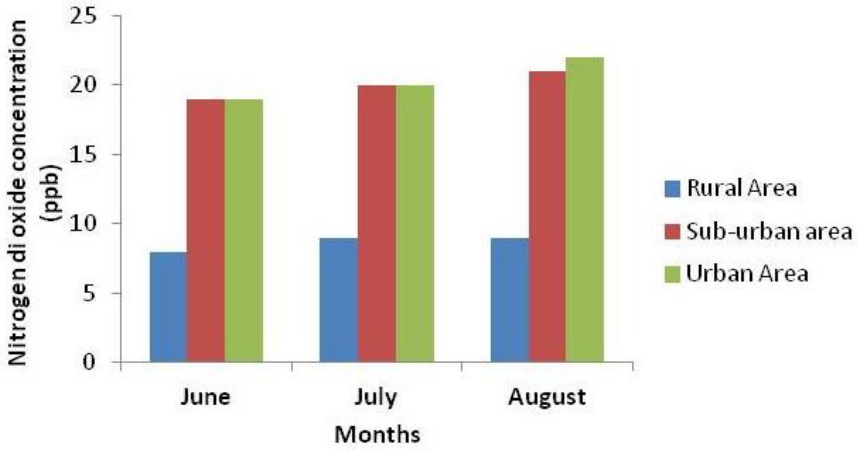


Figure 2.Average monthly reading of gaseous air pollutants [ozone, (Fig. A), sulfur dioxide (Fig. B) and nitrogen dioxide (Fig. C)] in sites of rural area, sub-urban area and urban Area.

Determination of carbohydrates

Results shown in Table (2) proved that there was an effect of air pollutants on the carbohydrates level in beans plant, where there were significant differences between the three sites under study as evidenced by the impact of the treatment with ascorbic acid concentrations. It was noted that the general trend is to increase the carbohydrates by increasing of ascorbic acid concentrations.

The results indicated that the monosaccharides, disaccharides and polysaccharides in the plants at the growing sites of the rural area were higher than at the site of the sub-urban area and the location of the urban area (Table 2) and (Figure 3A, B and C).

The highest content of monosaccharides, disaccharides and polysaccharides at ASA concentration of 300 mg/l were 8.1, 7.8 and 6.8 mg/g (Table 2) and (Figure 3A), 23.0, 22.8 and 21.8 mg/g (Table 2), (Figure 3B) and 38.8, 36.8 and 36.0 mg/g (Table 2) (Figure 3C) at the sites of rural area, the sub-urban area and urban area, respectively.

DISCUSSION

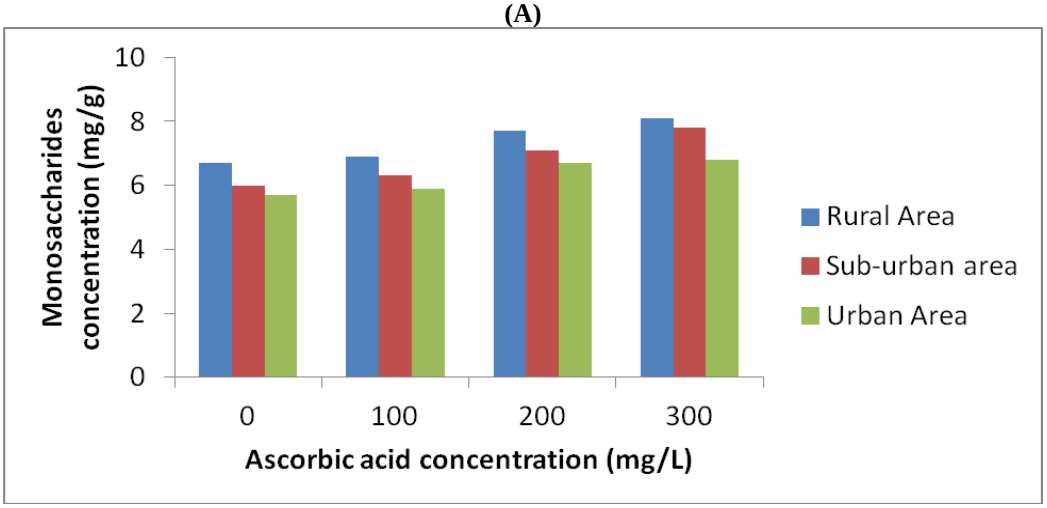
In recent decades, industrial development has a negative impact on the environment in the Riyadh region, Kingdom of Saudi Arabia. The excessive increasing the rates of emission of pollutants affects the plant physiology directly. The results of this study indicated that the concentration of ozone gas in the three locations under study exceeded the allowable limit global air pollution (25-30 ppb), and that the concentration at the site of rural area, less than the sites of sub-urban area and the urban area. On the other hand, the concentration of sulfur dioxide and nitrogen dioxide was not exceeded the limit of global air pollution (Castnet, 2004).

This study aimed to investigate the effect of treatment of different concentrations of ascorbic acid (0, 100, 200 and 300 mg/l) in minimizing the adverse impact of these gases on the plant. The results showed a difference between the rates of gaseous air pollutants, i.e., ozone and sulfur dioxide and nitrogen dioxide in the study sites. The data has revealed that there are significant differences in the content of monosaccharides, disaccharides and polysaccharides in the leaf tissues in the plants at these sites. The contents of these sugars were significantly reduced in the leaves of plants at the sites of the sub-urban area factory and cement compared with those plants at the site of the rural area due to an increase in the concentration of ozone. This result agrees with Sanmartin et al. (2003) work where it was proved that effect of ozone on the metabolism of the carbohydrates through its direct impact on the reactions of photosynthesis and indirectly through its impact on the stomata. It was noted that plants close their stomata in response to ozone to avoid toxicity. Furthermore, the production of low content of carbohydrates is due to a decrease of photosynthesis and impairment of carbon distribution (Drogoudi and Ashmore, 2002). This result also agrees with Iglesias et al. (2006) who reported the effect of ozone on decline of carbohydrates content in *Citrus clementina* plant. Our result was also line with Vorne et al. (2002) and Pell et al. (1988) who reported that the high concentration of ozone has led to a decrease in the content of sugars in the potato (*Solanum tuberosum* L.) plant as compared with those growing in unpolluted air. As the concentration of ascorbic acid is increases in the treatment, the content of carbohydrates increases as it improves the stress of the plants (Robinson, 1973). The results in this study also indicated that the content of monosaccharides, disaccharides and polysaccharides in beans leaves were increased by rise of ascorbic acid concentration. There were positive effects of ascorbic acid on the metabolism of carbohydrates, particularly activation of enzymes associated with metabolism of carbohydrates, through transfers of energy, and also improves the activity of the process of photosynthesis.

Table 2.Effect of ascorbic acid on the content of mono, di and polysaccharides (mg/g) in *P. vulgaris* plants growing at sites of gaseous air pollutants

Site	Ascorbic acid) mg/l(	Monosaccharides mg/g)(	Disaccharides) mg/g(	Polysaccharides) mg/g(
Rural area	Zero	6.7	21.7	35.6
	100	6.9	21.8	35.9
	200	7.7	23.8	37.7
	300	8.1	23.0	38.8
Sub-urban area	Zero	6.0	20.9	34.7
	100	6.3	21.0	34.8
	200	7.1	21.8	35.9
	300	7.8	22.8	36.8
Urban area	Zero	5.7	20.6	33.7
	100	5.9	20.8	34.1
	200	6.7	21.6	35.7
	300	6.8	21.8	36.0
L.S.D (0.05)		0. 30	0.31	0.33

(A)



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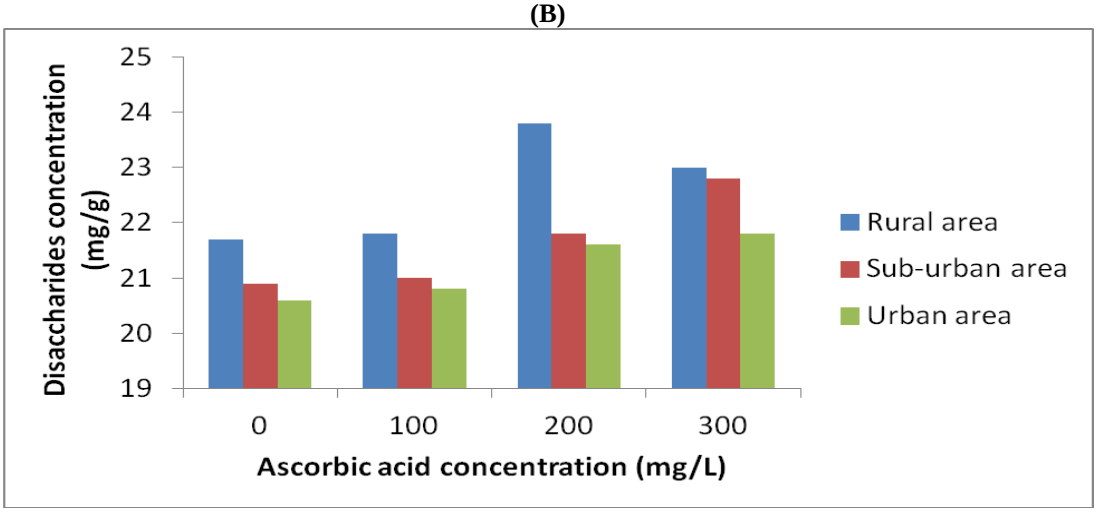

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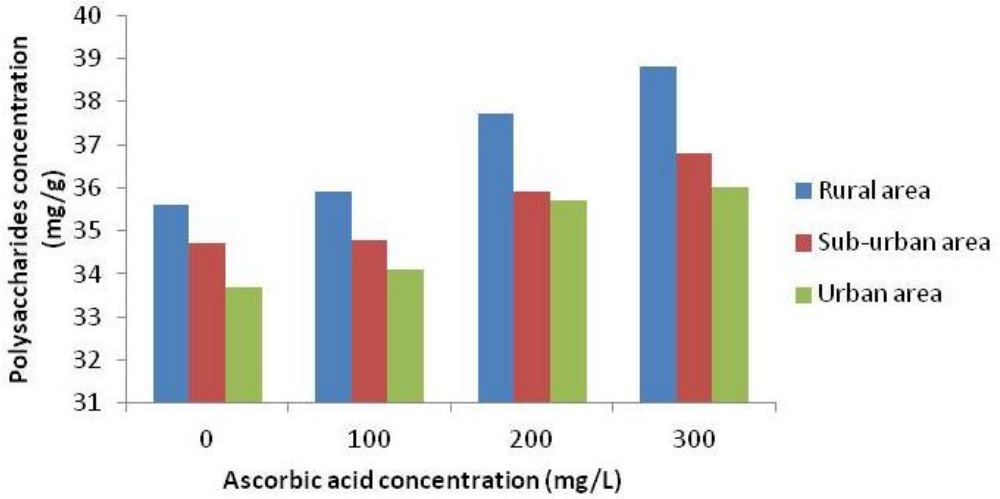

Figure3. Effect of ascorbic acid concentration on the content of monosaccharides (Fig. A), disaccharides (Fig. B), and Polysaccharides (Fig. C), in *P. vulgaris* plants growing in gaseous air pollutants sites

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