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EFFECT OF VEHICULAR POLLUTION ON FOLIAR PHYSIOLOGICAL CHARACTERISTICS OF TWO BUSHY ORNAMENTAL PLANTS OF KASHMIR HIMALAYAS

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ABSTRACT

The impact of vehicular pollution on foliar physiological sensitivities of two bushy ornamentals *Abelia grandiflora* Rehd. and *Lagerstroemia indica* L., growing in Srinagar (Kashmir), was assessed in year 2005 at two sites viz., Jahangir Chowk (highly polluted) and Jawahar Nagar (moderately polluted). The pollution stress significantly reduced chlorophyll *a*, *b* and total chlorophyll, N, P and K, total carbohydrate and ascorbic acid contents in plants but significantly increased proline content. *Lagerstroemia indica* was more vulnerable to air pollution than *Abelia grandiflora.*

Keywords: Bushy ornamentals, Kashmir, physiological parameters, vehicular pollution

INTRODUCTION

Certain plants are considered as good monitors of air pollution. The proponents of green belt to protect the urban environment from industrial pollution heavily rely on this environmental concept. In recent past the air quality of Srinagar city has been rapidly changing due to expanding urbanization and use of increasing number of vehicles. The data provided by the Department of Traffic Police, Srinagar city indicates 1,56,991 registered vehicles plying on different routes of Srinagar city and there has been 160% increase in vehicular traffic during past decade. Moreover, on an average 82,167 tourist and goods carrying vehicles annually ply on different routes of Kashmir valley.

Many workers have reported deleterious effects of vehicular pollution on the growth performance of different plant species (Wagh *et al.*, 2006; Joshi *et al.*, 2009). The growing vehicular pollution in Srinagar city urges research on assessing the impact of automobile exhausts on foliar physiological activities of plants grown in Kashmir Himalayas (Lone and Khan, 2007a,b) and also to combat pollution stress by plantation of suitable tolerant species. The present study was undertaken to assess the foliar sensitivity of two commonly grown ornamental bushy plants (*Abelia grandiflora* Rehd. and *Lagerstroemia indica* L.) under ambient field condition at high and moderately polluted sites in Srinagar city, the summer capital of Jammu & Kashmir State.

MATERIALS AND METHODS

Srinagar city is situated between 33°-14’ and 30° -25’ north latitude and 74°- 38’ east longitude in the Himalayan State of Jammu & Kashmir. The climate of the area is temperate with four distinct seasons, autumn, winter, spring and summer. The concentration of suspended particulate matter (SPM), NO_x

and SO_2 in air were monitored at each site with the help of High Volume Sampler (Envirotech APM-430). The concentration of SPM was determined gravimetrically using filter paper method and the concentration of NO_x and SO_2 was measured with standard methods (Jacob and Hochheiser, 1958).

The foliage samples were collected from the experimental plants *Abelia grandiflora* (10 years old) and *Lagerstroemia indica* (8 years old) during three seasons (spring, summer and autumn in 2005) from the road side bushes at the selected sites viz., heavily polluted (Jahangir Chowk) and moderately polluted (Jawahar Nagar). Shalimar campus, SKUAST-K, lying 15 km away from the Srinagar city on east, served as control site. Five individual plants (serving as replicates) of uniform age group were selected from each site. From each replicate, 50 foliage samples were randomly collected from individual tree species from all sides of canopy and mean values obtained. A randomized block design was used for the experiment. Standard methods were used for the estimation of photosynthetic pigments (Hiscox and Israelstam, 1979), N, P and K (Jackson, 1973), ascorbic acid, proline and total carbohydrate (Sadasivum and Manikam, 1992) in leaf samples. Composite soil samples were collected from different places at each site, mixed properly and air dried. The pH, electrical conductivity, available N, P and K and organic matter contents of soil were estimated as per standard methods (Jackson, 1973). The data was artistically using analysis of variance.

RESULTS AND DISCUSSION

The air quality at different study sites revealed that SPM was 391 μg^{-3} at highly polluted site (Jahangir Chowk) followed by Jawahar Nagar (136 $\mu g\ m^{-3}$) and low at control site (104 $\mu g\ m^{-3}$). Similarly, other gaseous pollutants viz., NO_x and SO_2 were higher at highly polluted site (146 and 18 $\mu g\ m^{-3}$) and low at control site (1 and 0.05 $\mu g\ m^{-3}$) [Table 1]. The meteorological conditions during study period are given in Table 2. The photoreceptors chlorophyll *a* and *b* in chloroplasts of green plants are essential for photosynthetic activity. Relatively low photosynthetic pigment contents (chlorophyll *a*, *b* and total chlorophyll) were noticed in plants growing at Jahangir Chowk (highly polluted site) compared to Jawahar Nagar (moderately polluted site) in all the seasons (Fig. 1). The interactive effect of sites, species and seasons on various physiological parameters of plants revealed that pigment content in both species suffered significant losses due to the pollution stress, with highly polluted site showing more losses than moderately polluted site (Table 3). Moreover, both the species experienced higher losses in summer season than spring or autumn. The losses in chlorophyll contents in all seasons were higher in *Lagerstroemia indica* compared to *Abelia grandiflora* (Table 4). The degradation of chlorophyll pigment might be due to the production of superoxide radicals by the action of sulphite with chlorophyll under illumination or due to the action of SO_2 or NO_2 (constituents of vehicular emissions) on chlorophyll metabolism (Lauenroth and Dodd, 1981). The decrease in chlorophyll pigment might have been caused by the shading effect due to the deposition of suspended particulate matter on leaf surface at the polluted sites which may have clogged the stomata and interfered with gaseous exchange. This may lead to increased leaf temperature which may consequently retard chlorophyll synthesis. A study carried out on pigment changes in Norway spruce induced by dust pollution has shown less availability of light under dust pollution leading to decreased elemental

Table 1: Volume of traffic and concentration of SPM, NO_x and SO_2 ($\mu g\ m^{-3}$) at Jahangir Chowk (highly polluted site), Jawahar Nagar (moderately polluted site) and at Shalimar (control site) [average values in a year]

Site	Volume of traffic (No. of vehicles plying hr^{-1})				Conc. of pollutants ($\mu g\ m^{-3}$)		
	Morning	Afternoon	Evening	Average	SPM	NO_x	SO_2
Jahangir Chowk	4708	4468	3916	4364	391	146.0	18.00
Jawahar Nagar	1436	1144	1234	1271	136	10.0	3.00
Shalimar campus	48	30	40	39	104	1.0	0.05

Table 2: Average meteorological data recorded in Srinagar during the study period

Month/year	Season	Temperature (°C) Maximum	Minimum	Mean	Rainfall (mm)	Relative humidity (%)
March 2005		13.5	4.2	8.84	1.88	74.4
April 2005	Spring	9.95	5.6	12.77	1.19	59.0
May 2005		0.78	8.5	14.62	2.30	70.7
June 2005		29.0	12.5	20.75	0.43	58.8
July 2005	Summer	28.6	16.6	22.60	2.90	72.7
August 2005		30.4	15.5	22.95	0.97	66.0
September 2005		28.5	11.1	19.80	0.23	65.3
October 2005	Autumn	19.8	5.6	12.70	0.98	73.3
November 2005		16.8	0.2	8.50	0.60	70.6

Source: Division of Agronomy, SKUAST-K

Table 3: Effect of site, plant species and season on various physiological parameters of leaves

Sites	Species	Season	Chlorophyll ($mg\ g^{-1}$ fresh wt.) *a*	*b*	Total	Macronutrients (%) N	P	K	Total carbohydrate (%)	Proline (μ mol g^{-1} fresh wt.)	Ascorbic acid (mg g^{-1} fresh wt.)
Jahangir Chowk (highly polluted)	*Abelia grandiflora*	Spring	0.34	0.29	0.63	1.71	0.15	0.85	8.35	1.778	0.070
		Summer	0.88	0.73	1.61	1.87	0.18	1.10	10.01	2.646	0.134
		Autumn	0.47	0.41	0.89	1.64	0.13	0.87	7.93	1.928	0.075
	Lagerstroemia indica	Spring	0.41	0.34	0.75	1.58	0.16	0.84	7.99	2.244	0.084
		Summer	0.68	0.67	1.36	1.73	0.18	0.91	9.95	3.393	0.145
		Autumn	0.31	0.25	0.57	1.39	0.10	0.75	7.26	2.086	0.078
Jawahar Nagar (moderately polluted)	*Abelia grandiflora*	Spring	0.38	0.32	0.70	1.90	0.18	0.92	9.25	1.666	0.077
		Summer	0.98	0.80	1.78	2.07	0.20	1.18	11.18	2.389	0.148
		Autumn	0.54	0.46	1.00	1.79	0.15	0.92	8.78	1.794	0.083
	Lagerstroemia indica	Spring	0.47	0.38	0.85	1.74	0.17	0.86	8.88	2.108	0.096
		Summer	0.77	0.73	1.51	1.90	0.19	1.00	10.92	3.147	0.163
		Autumn	0.35	0.28	0.46	1.49	0.11	0.84	8.04	2.022	0.087
SKUAST-K (control)	*Abelia grandiflora*	Spring	0.44	0.36	0.80	2.25	0.21	1.14	10.50	1.400	0.090
		Summer	1.18	0.92	2.10	2.50	0.24	1.43	13.00	1.975	0.175
		Autumn	0.63	0.51	1.14	2.11	0.17	1.11	10.04	1.495	0.095
	Lagerstroemia indica	Spring	0.60	0.46	1.06	2.20	0.22	1.14	11.10	1.700	0.110
		Summer	1.02	0.93	1.95	2.47	0.26	1.29	14.01	2.459	0.192
		Autumn	0.45	0.34	0.79	1.91	0.14	1.07	9.81	1.605	0.100
$LSD_{0.05}$			0.11	0.04	0.13	0.55	0.03	0.05	1.64	0.134	0.019
S.E.$\pm$			0.06	0.02	0.06	0.03	0.01	0.03	0.81	0.066	0.009

uptake and inhibition in the absorption of active parts of solar radiation involved in photosynthesis (Mandre and Tuulmets, 1997). Some authors believe that air pollutants like sulphur dioxide exert adverse effects on plants by destroying the cellular molecules and ultimately inducing alterations in metabolic pool (Mandloi and Dubey, 2000). Reductions in chlorophyll content may be due to the increase in chlorophyllase enzyme activity which, in turn, affects the chlorophyll concentration in plants (Mandal and Mukherji, 2000). Such losses in chlorophyll contents induced by air pollutants have also been reported earlier (Wagh, *et al.*, 2006; Joshi *et al*., 2009). It is evident that in all the investigated species, chlorophyll *a* recorded more severe losses due to vehicular pollution compared to chlorophyll *b*. The higher sensitivity of chlorophyll *a* to vehicular pollution might be ascribed to the inactivation of enzymes associated with the synthesis and action of chlorophyll *a* as reported earlier (Lone and Khan, 2007a,b). The concentration of essential mineral nutrients like N, P and K invariably decreased in the foliage of polluted populations but the losses were more in *Lagerstroemia indica* than in *Abelia grandiflora*. In both species higher losses were seen in the samples collected from heavily polluted site, Jahangir Chowk followed by the samples collected from moderately polluted Jawahar Nagar (Table 4). The nitrogen depletion may be due to the loss in protein synthesis or due to the inactivation of enzymes responsible for protein synthesis. The loss of N may also be responsible for decreased chlorophyll levels as observed in present study. Decline in P level indicated the inhibition of certain enzymatic activities involved in P metabolism. Further, plants growing under stress conditions have the tendency to loose more energy (ATP/NADPH) and thus utilize P to the maximum possible extent (Rehana *et al.*, 2004).

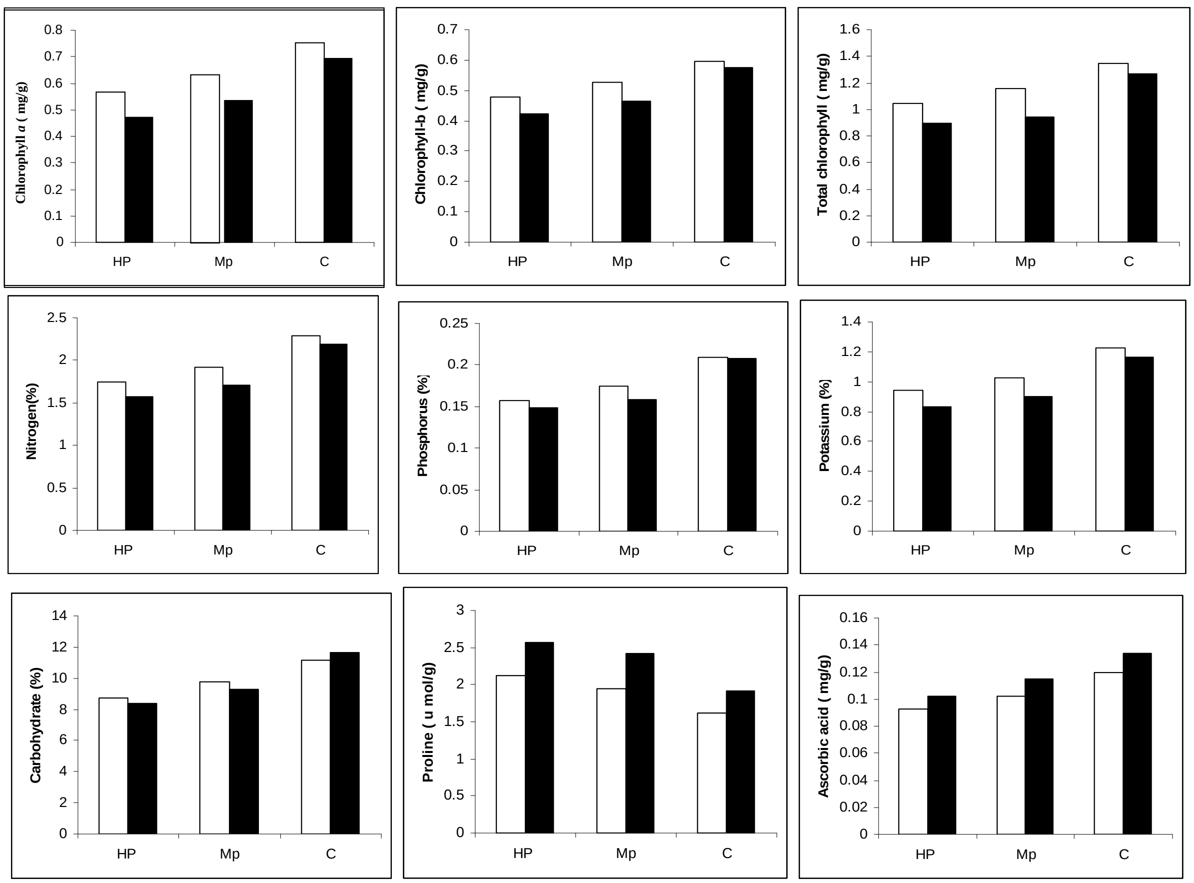

Fig. 1: Variation in ncentration of some physiological parameters of *A. grandiflora* ( ) and *L. indica* ( ) growing at highly polluted (HP), moderately polluted (MP) and control (C) sites.

This phenomenon may ultimately lead to exhaustion of P in plants under stress. K losses observed in the foliage of plants, affected by pollution, indicated that the vehicular pollution hampers the K metabolic activities (Rehana *et al*., 2004). Deficient N, P and K levels in soil (Table 5) may account for decreased N, P and K levels in the foliage of test species. Air pollution induced changes may cause greater solubility (and mobility) of soil constituents especially P which may leach from the rooting zone and become unavailable for plant growth. The data also shows that *Lagerstroemia indica* recorded more reductions in carbohydrate content in the population growing at the polluted site as compared to *Abelia grandiflora* (Fig. 1). Such reductions are in agreement with earlier observations (Rehana *et al*., 2004). The losses in carbohydrate contents may be attributed to the increased respiration and/or due to reduced CO_2 fixation/or due to reduced photosynthetic activity because of

Table 4: Seasonal changes (percent variations) in various physiological parameters of *Abelia grandiflora* and *Lagerstroemia indica* at study sites

Sites	Species	Season	Chlorophyll ($mg\ g^{-1}$ fresh weight) *A*	*B*	Total	Macronutrients (%) N	P	K	Total carbo-hydrates (%)	Proline (μ mol g^{-1} fresh wt)	Ascorbic acid ($mg\ g^{-1}$ fresh wt)
Jahangir Chowk (highly polluted)	*Abelia grandiflora*	Spring	-22.5	-18.2	-20.9	-24.0	-26.2	-25.0	-20.5	+27.0	-22.22
		Summer	-25.0	-21.0	-23.3	-25.0	-24.6	-23.0	-23.0	+34.0	-23.42
		Autumn	-24.1	-19.1	-21.8	-22.0	-23.7	-22.1	-21.0	+29.0	-22.00
	Lagerstroemia indica	Spring	-32.0	-25.1	-29.0	-28.0	-27.3	-26.1	-28.0	+32.0	-23.63
		Summer	-33.0	-27.1	-30.2	-30.0	-29.2	-29.1	-29.0	+38.0	-24.47
		Autumn	-30.0	-24.6	-27.7	-27.0	-30.3	-30.0	-26.0	+30.0	-21.05
Jawahar Nagar (moderately polluted)	*Abelia grandiflora*	Spring	-13.3	-11.2	-12.8	-15.5	-15.2	-16.0	-12.0	+19.0	-14.44
		Summer	-17.0	-13.0	-15.2	-17.0	-17.1	-17.1	-14.0	+20.9	-15.42
		Autumn	-14.0	-10.1	-12.3	-15.0	-16.4	-17.0	-12.5	+20.0	-13.00
	Lagerstroemia indica	Spring	-22.0	-17.0	-19.8	-21.0	-23.2	-24.0	-20.0	+24.0	-12.70
		Summer	-25.2	-20.6	-22.7	-23.0	-24.2	-22.0	-22.0	+28.0	-15.10
		Autumn	-21.0	-16.0	-18.9	-22.0	-22.1	-21.6	-18.0	+26.0	-12.63

- = decrease from control; + = increase from control

Table 5: Some physicochemical characteristics of soils at the study sites

Sites	pH	EC (dsm^{-1})	Available NPK ($kg\ ha^{-1}$) N	P	K	Organic carbon (%)	Extract-able Ca (c mol g^{-1})	Extract-able-Mg (c mol g^{-1})	Other nutrients (ppm) Fe	Al	Cu	Zn
Jahangir Chowk	7.04	0.13	205	15.0	134	0.85	4.45	0.35	26.1	2.80	1.08	1.48
Jawahar Nagar	7.15	0.18	290	16.5	168	1.08	4.55	0.35	26.0	2.79	1.08	1.48
Shalimar	7.26	0.27	380	19.6	338	1.15	5.88	0.37	25.8	2.74	1.10	1.47

reductions in photosynthetic pigment content. However, other authors (Pierre and Queiroz, 1981) believe that carbohydrate level reduction are independent of chlorophyll loss and holds a number of key enzymes as the primary targets of gaseous pollutants. It is also reported that closure of stomata in response to motor emissions causes a decrease in transpiration and CO_2 uptake which ultimately results in decreased photosynthesis and consequently carbohydrate decline. Ascorbic acid acts as reductant and helps in the scavenging of free radicals which are excessively formed in plants subjected to air pollution stress. It plays an important role in pollution tolerance as it acts as a natural antioxidant reacting with hydrogen peroxide and protects carotenes and tocopherols (Perl-Treves and Perl, 2002). In present study, both the species growing at polluted sites showed decline in ascorbic acid content, though more in *Lagerstroemia indica* compared to *Abelia grandiflora* (Fig. 1). In presence of gaseous air pollutants, the ascorbic acid might be reduced to dehydro-ascorbic acid or oxalic acid and/or other convertible carbohydrates or it may be due to enzyme toxicity and sulphonation of SH groups. Reduction in the ascorbic acid in the foliage of the plants affected by air pollution has also been reported by several other workers (Joshi and Swami, 2007; Joshi *et al*., 2009). Proline is an amino acid found in higher percentage in basic proteins. Free proline seems to play a role in plants under stress conditions by acting as free radical scavenger to protect plants from damage by oxidative stress. Although the scavenging action of reactive oxygen species with other amino acids such as tryptophan, tyrosine, histidine, etc. are more effective compared to proline. Proline is of special interest because of its extensive accumulation in plants during environmental stress (Wang *et al.*, 2009). It is believed that under stress conditions protein break down into amino acids and conversion to proline for storage. In this study proline contents in foliage of plants growing at polluted sites exhibited elevated trends in both species (Fig. 1), thus signifying the breakdown of proteins under stress conditions. The higher increase was, however, observed in *L. indica* compared to *A. grandiflora*. The increase in proline contents in plants growing under air pollution stress has been observed by Seyyednejad *et al.* (2009). In conclusion, the comparison of several physiological parameters of leaves showed that *Lagerstroemia indica* is more sensible to air pollution compared to *Abelia grandiflora.* Thus the use of *A. grandiflora* as a natural sink of pollutants looks promising to mitigate air pollution hazards in urban environments.

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