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ALSTONIA SCHOLARIS (L.) R.Br.- PLANTED BIOINDICATOR ALONG DIFFERENT ROAD-SIDES OF LAHORE CITY

SOHAIB MUHAMMAD[1*], ZAHEER-UD-DIN KHAN[1], AYESHA ZAHEER[2], MUHAMMAD FAHEEM SIDDIQUI[3*], MUHAMMAD FAISAL MASOOD[4] AND ATTA MUHAMMAD SARANGZAI[5]

[1]Department of Botany, [2]Sustainable Development Study Center, GC University, Lahore, Pakistan (54000)
[3]Department of Botany, University of Karachi, Karachi-75300, Pakistan
[4]Forest GIS Laboratory, Lahore, Pakistan
[5]Department of Botany, University of Baluchistan, Quetta-Pakistan
[*]Corresponding e-mail: sohaibs1983@gmail.com; mfsiddiqui2011@yahoo.com

Abstract

A research work was carried out during 2009-2011 to investigate the biomonitoring potential of a road avenue tree, *Alstonia scholaris* (L.) R.Br. against the culminating pressure of aerial pollution in Lahore city. For this purpose seven busiest roads were selected on the basis of the flux of traffic and three leaf samples were taken for various biochemical and physiological attributes from each of the *A. scholaris* tree of respective road. The geographic coordinates on the map can be used for future reference. Various floral attributes of plant were selected i.e., amount of dust (g), percent (%) leaf moisture content, photosynthetic rate ($\mu Mm^{-2}S^{-1}$), transpiration rate ($\mu Mm^{-2}S^{-1}$), stomatal conductance ($mMm^{-2}S^{-1}$), chlorophyll contents (mg/g) and amount of carotenoids (mg/g) in the leaf samples. In case of % leaf moisture content, significant variation between the control (61.95) and road side plants (50.76) was observed. While minute differences between the control and road side plants were recorded in photosynthetic rate, transpiration rate, stomatal conductance, chlorophyll contents and carotenoids, which is an indication that day by day increasing air pollution pressure in Lahore city is playing pivotal role, not only in the morphological features of the plant but also affecting the physiological and biochemical characteristics of the plant.

Introduction

The pollutant can be any substance which alters environmental constituents or the constituents in the wrong amount at the wrong place or at the wrong time, causing the pollution. Thus air pollution means qualitative and quantitative changes in the atmospheric constituents due to addition or contamination of such substances which may be harmful to man and its environment. Air pollution can be categorized into indoor (pollution of atmosphere inside a building) and outdoor pollution (atmospheric pollution in the open space) (Shukla & Chandel, 2006).

Air pollution is escalating day by day mainly because of five specific reasons viz., industrialization of countries, expansion of cities, increase in traffic, rapid economic development and higher level of energy consumption. In many developing countries, the growth of both industrial and residential areas is unplanned, unstructured and un-zoned, thus creating the ever increasing problem of the air pollution. In urban areas the main source of pollution are power plants, industries, motor vehicles and domestic activities. Combustion of fossilized fuel in industry and automobiles extend to the production of oxides of sulphur, nitrogen, carbon and particulate matter in the form of fly-ash and soot and secondary particulate matter like sulphate (SO_4^{-2}) and nitrate (NO_3^-) aerosols, etc. (Yunus & Iqbal, 1997). Above all, use of the motor vehicles is growing fast in the developing countries especially in Asia since, 1979 (Anon., 1987). Rapid increase in automobiles results in high pressure of air pollution, badly affecting human health, ecosystems and materials with corresponding economic losses. However, many Asian cities like Lahore have to suffer from the pressure of a combination of different driving forces, which are occurring simultaneously, each with a greater intensity than has occurred elsewhere or in the past (McGranahan *et al*., 2001). Apart from the hazardous effects on human health, the air pollution affects the plants badly at different levels of organization. Plants have their role in carbon dioxide sequestration and oxygen release through photosynthesis and in air temperature by shading and transpiration besides adding ornamental beauty to urban life (Akbari, 2002; Brack, 2002; Gratani *et al*., 2008). Air pollution has also tremendous effects on the plant diversity at different levels of organizations like species level diversity is the most studied element of biological diversity in relation to atmospheric pollutants (McClenahen, 1985; Heywood & Baste, 1995).

A number of bio-indicators have been evaluated for biomonitoring of air pollution, such as lower plants like mosses, lichens and higher vascular plants like angiosperms and gymnosperms along with their barks but among them tree vegetation is found to be the best bio-monitors of air pollution (Del-Rio *et al*., 2002; Madejon *et al*., 2006). Road side vegetation can be successfully used as bioindicators of trace elements, as tissues of plants have the ability to slot in these trace elements through different sources such as soil and foliage structures (Monaci *et al*., 2000). Impact of air pollution has been studied in different parts of the world on different plant species. As Dineva (2004) conducted an experiment to compare the leaf morphology and structure of *Fraxinus americana* L. and *Platanus acerifolia* Willd. growing in the polluted area. The air-borne particulate matter on the roadside plantation adversely affects the morphological and anatomical features including the clogging of stomata of the plants (Shafiq & Iqbal, 2005). Automobile exhaust pollution contains dust and various gaseous compounds which affect not only the human health but also affect the growth of the plants in different ways (Sher & Hussain, 2006). Dzomeku & Enu-Kwesi (2006) studied eco-physiological characters of two tree species, i.e., *Azadirachta indica* and *Millettia thonningii* under different pollution stresses.

Lahore being the capital of the province has highest rates of the automobiles in the city which are contributing towards the congestion of the vehicles resulting in devastating increase in air pollution. It is not only affecting the health of the humans but also to the floral diversity of the urban habitat. So, keeping in mind the affects the present research work was designed to check the impact of automobile exhaust on one of the planted tree along different road sides of the Lahore city. The investigated plant was found widely distributed indicating its diverse nature of ecological elasticity. Therefore, the main idea was to investigate the potential of *Alstonia scholaris* (L.) R.Br. as bioindcator of air pollution through various physiochemical analysis.

Materials and Methods

On the basis of the reports of Environment Protection Agency (EPA), Punjab (Anon., 2002), seven busiest roads of Lahore city were selected and marked as R1, R2, R3, R4, R5, R6 and R7. The plantation on these road sides was studied and a list of the plants was prepared. In order to define the vegetation profile of the busiest roads of the Lahore city the plants were categorized into trees, shrubs and herbs after Mueller-Dombois & Ellenberg (1974). Among all the plant species *Alstonia scholaris* (L.) R.Br. was found to be present in all the respective study sites of the Lahore city. Each road was further divided into five sub-sites for sampling. The geographic coordinates were taken by GPS (Garmin eTrex Venture HC). Various attributes were studied to test *A. scholaris* as bioindicator for Lahore city against the control samples collected from the GCU, Botanic Garden or from less polluted areas (Fig. 1). The amount of dust (g) and % leaf moisture content was calculated after Hussain (1989). While photosynthetic rate ($\mu Mm^{-2}S^{-1}$), transpiration rate ($\mu Mm^{-2}S^{-1}$), stomatal conductance ($mMm^{-2}S^{-1}$) were determined with the help of Infra Red Gas Analyzer (IRGA, LCA-4) after Wahid *et al*., (2001). Moreover, chlorophyll contents (mg/g) and amount of carotenoids (mg/g) in the leaf samples were recorded by using UV- spectrophotometer (Spectro-scan, 80-D UV-VIS) by using standard procedure after Yoshida *et al*., (1972) and Zofia *et al*., (2006) respectively.

Results and Discussion

In total six plant samples (each sample having three replicates) of the *A. scholaris* were collected. One sample taken from less polluted areas served as control while five (S1, S2, S3, S4 and S5) samples were taken from different sub-sites of the main road side. These plant samples were tested against different variables. The amount of dust (g) deposited on the leaves of the samples varied significantly. An increase in the amount of the dust on leaf samples along road sides was found as compared to the control plant samples, as shown in Table 1. Moreover, moisture contents (%) of the plant leaf samples varied not only within the plant samples but also with in the different road sides as Table 1 indicated a decrease in moisture contents of the plant samples collected from the road site as compared to the control plant samples.

Data on photosynthetic rate ($\mu Mm^{-2}S^{-1}$) showed in Table 2 indicated that photosynthetic rate of control, were higher from the rest of the plant samples of the road sides. Results showed that the photosynthetic rate ($\mu Mm^{-2}S^{-1}$) of the control plants was 19.30, 21.03, 22.76, 21.07, 20.15, 19.40 and 22.41 as compared with the mean values of photosynthetic rate of each road side having 16.19, 20.91, 22.10, 20.63, 19.91, 18.35 and 21.99 in R1, R2, R3, R4, R5, R6 and R7 respectively. Plants usually transpire due to the metabolic activities occurring and are regarded as the necessary function of the plants. Data entered in Table 2 showed higher transpiration rate in the control plants as compared to the plant samples of road site. Comparative results showed that the mean transpiration rate ($\mu Mm^{-2}S^{-1}$) of the control plants was found 1.70, 0.67, 1.43, 1.50, 1.93, 1.80 and 1.55 of the respective seven road sides as compared with the control samples having 1.52, 0.57, 1.31, 1.49, 1.84, 1.60 and 1.36 transpiration rate in road side plants. The variations in the stomatal conductance of the plant samples from the road sides and the control one were recorded in Table 2. A significant variation was found in case of stomatal conductance ($mMm^{-2}S^{-1}$) as its values in control plants were 0.93, 1.03, 0.99, 0.98, 0.89, 0.95 and 0.98 for respective seven road sides. While stomatal conductance of road side plants were observed as 0.86, 0.93, 0.63, 0.86, 0.74, 0.91 and 0.79 showing marked disturbance in physiological process of the plant. From the above mentioned results it can be concluded that attributes taken from those areas of the road side having dense vegetation, e.g. the well planted portion of the Mall road (R1) has less amount of the values of all the parameters and found almost very close to the values of control one taken from the GCU Botanic Garden as described by Dzomeku and Enu-Kwesi (2006). Amount of the dust on the plants from the road side was found to be greater as compare to the selected control plant specimens and in case of % leaf moisture contents the case was found vice versa. Greater number of the automobiles on the roads and the bad functioning of the engines resulting in the burnt fossil fuels which ultimately results in the deposition of the dust on the road side vegetation, so the plant's physiological attributes like photosynthetic rate, transpiration rate, stomatal conduactance and gaseous exchange of the plants with the environment can be get affected as observed in this study coinciding the views of Monaci *et al*., (2000), Allen *et al*., (2001), Harrison *et al*., (2003), Riga & Saitanis (2004), Wahlin *et al*., (2006) and Peachy *et al*., (2009).

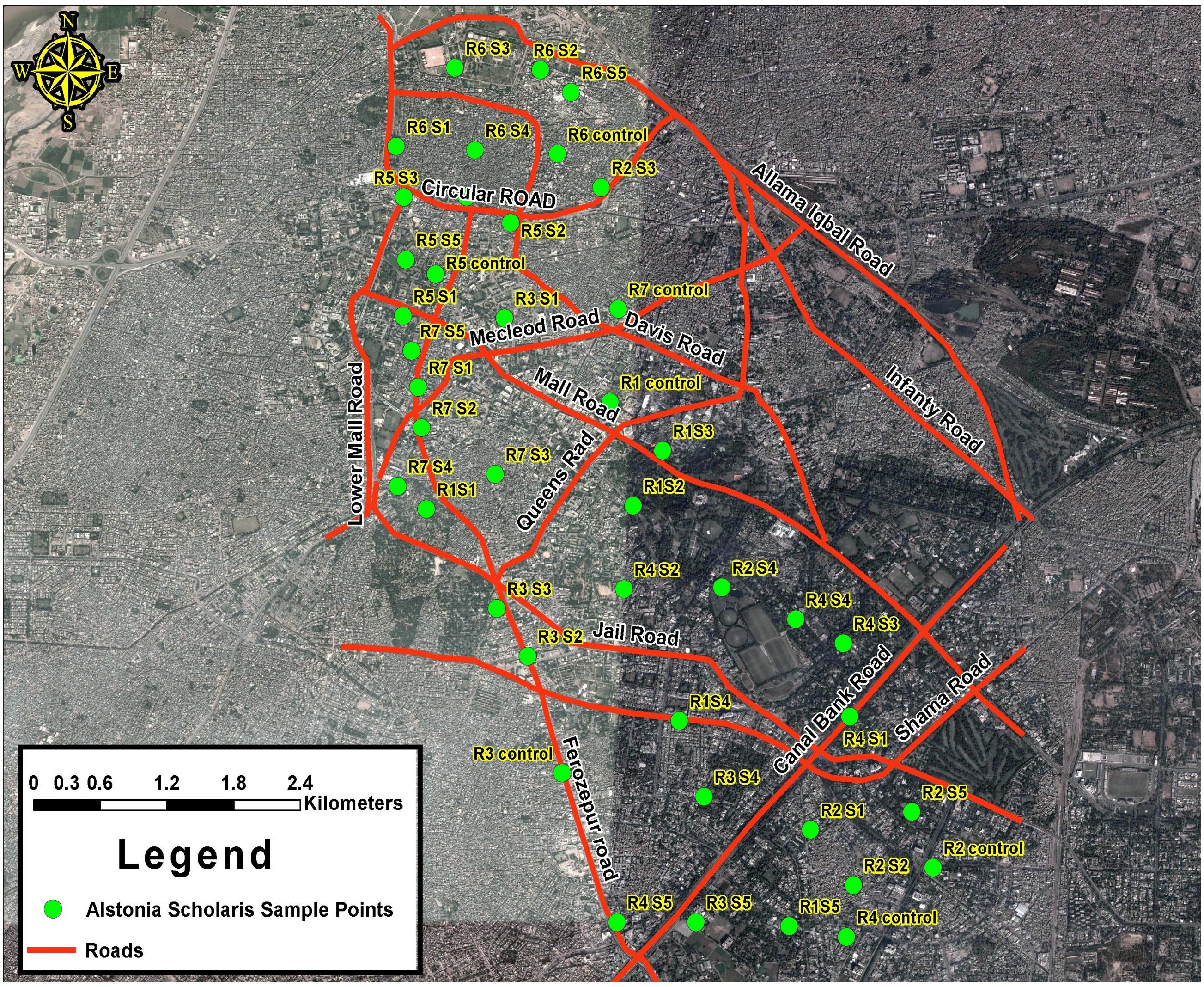

Fig. 1. *Alstonia scholaris* sampling points at different road sides of Lahore city.

Table 1. Amount of dust (g) and leaf moisture contents (%) of *Alstonia scholaris* in different road sides of Lahore city.

Road sides	Amount of dust (g)		% Leaf moisture contents	
	Control	Experimental	Control	Experimental
R1	0.05c ± 0.01	0.06ab ± 0.001	59.25a ± 0.11	35.73c ± 0.08
R2	0.04d ± 0.001	0.07b ± 0.02	65.13b ± 0.08	53.11b ± 0.07
R3	0.04c ± 0.02	0.13b ± 0.03	65.13b ± 0.08	56.29bc ± 0.57
R4	0.09d ± 0.05	0.05bc ± 0.04	65.56a ± 2.11	57.33b ± 0.25
R5	0.03c ± 0.001	0.10ab ± 0.08	58.77ab ± 0.13	48.23bc ± 0.16
R6	0.06c ± 0.01	0.12b ± 0.02	54.35a ± 0.06	51.27a ± 0.77
R7	0.04c ± 0.02	0.12ab ± 0.05	65.64a ± 0.08	53.41d ± 0.57
Mean values	0.05c ± 0.03	0.09b ± 0.03	61.95a ± 0.10	50.76b ± 0.09

Note: Sample means followed by different letters in each column are significantly different from each other at p = 0.05

Table 2. Impact of automobile exhaust on photosynthetic rate, transpiration rate (µMm^{-2}S^{-1}) and stomatal conductance (mMm^{-2}S^{-1}) of *A. scholaris* in different road sides of Lahore city.

Road sides	Photosynthetic rate (µMm^{-2}S^{-1})		Transpiration rate (µMm^{-2}S^{-1})		Stomatal conductance (mMm^{-2}S^{-1})	
	*Con.	*Exp.	*Con.	*Exp.	*Con.	*Exp.
R1	19.3a ± 0.04	16.19bc ± 0.12	1.7a ± 0.05	1.52bc ± 0.13	0.93a ± 2.13	0.86a ± 0.43
R2	21.03a ± 1.45	20.91a ± 0.65	0.67ab ± 0.09	0.57a ± 0.07	1.03a ± 0.13	0.93ab ± 0.08
R3	22.76a ± 0.11	21.10a ± 0.67	1.43a ± 0.08	1.31a ± 0.05	0.99a ± 0.03	0.63b ± 0.10
R4	21.07a ± 0.45	20.63ab ± 1.26	1.50ab ± 0.03	1.49b ± 0.10	0.98ab ± 0.06	0.86ab ± 0.10
R5	20.15a ± 0.05	19.91ab ± 0.33	1.93a ± 0.05	1.84a ± 0.10	0.98ab ± 0.06	0.74a ± 0.12
R6	19.4a ± 0.04	18.35ab ± 0.71	1.80a ± 0.05	1.60b ± 0.35	0.95ab ± 0.11	0.91a ± 0.13
R7	22.41a ± 0.09	21.99a ± 1.33	1.55a ± 0.21	1.36b ± 0.09	0.98a ± 0.05	0.79cd ± 0.11
Mean values	20.87b ± 0.08	19.86b ± 1.12	1.51a ± 0.23	1.38a ± 0.11	0.97b ± 0.07	0.68b ± 0.11

Note: Sample means followed by different letters in each column are significantly different from each other at p = 0.05
Key to abbreviations: *Con.= Control and ***Exp.=** Experimental

Table 3. Impact of automobile exhaust on total chlorophyll and carotenoid contents (mg/g) of *A. scholaris* of different road sides of Lahore city.

Road sides	Total chlorophyll (mg/g)		Carotenoide contents (mg/g)	
	Control	Experimental	Control	Experimental
R1	4.43a ± 0.05	4.08d ± 0.23	5.65a ± 1.13	5.45cd ± 0.28
R2	4.56a ± 0.11	4.15c ± 0.11	5.43a ± 0.16	5.17cd ± 0.12
R3	4.32a ± 0.11	4.01cd ± 0.11	5.73a ± 0.21	5.22cd ± 0.26
R4	4.21a ± 0.12	4.01cd ± 0.15	5.13a ± 0.12	4.96de ± 0.42
R5	4.13a ± 0.13	3.88c ± 0.21	5.21a ± 0.13	5.08c ± 0.20
R6	4.83a ± 0.13	4.39cd ± 0.10	5.13a ± 0.13	4.98d ± 0.01
R7	4.12a ± 0.13	3.95c ± 0.11	5.43a ± 2.11	5.26d ± 0.95
Mean values	4.37b ± 0.14	3.49c ± 0.11	5.38b ± 1.23	5.16c ± 0.63

Note: Sample means followed by different letters in each column are significantly different from each other at p = 0.05

Results of total chlorophyll contents are depicted in Table 3. Comparative results of the seven road sides regarding the total chlorophyll contents (mg/g) in the control plants were found to be 3.45, 3.56, 2.92, 3.65, 3.48, 3.23 and 3.63 and these values were compared with the mean values of sample plants which were 2.83, 3.14, 2.32, 3.15, 3.03, 3.01 and 3.27 respectively in R1, R2, R3, R4, R5, R6 and R7 respectively. Carotenoids, the accessory components of the chloroplast showed variation in the plant samples in the present study. The amount of carotenoide contents were found fluctuating not within the plants of the same road but also in between the seven respective road sides as the results indicated in Table 3. The carotenoide contents of the road side plants were found to be 5.86 in R1, 6.00 in R2, 5.63 in R3, 6.05 in R4, 5.69 in R5, 5.82 in R6 and 6.00 in R7 which were compared with the control plant samples values which were 6.11, 6.17, 5.96, 6.13, 5.88, 5.97 and 6.12 in respective seven road sides. Same trend was found by the Sher & Hussain (2006) which confirms that effects of the air pollution is increasing with drastic increase in the number of the vehicles, cosmopolitan activities and the bad management of the traffic flow. Although widening of the roads with the well paved ends and the suitable road side plantation played its role in combating the air pollution problems (Bryant *et al.,* 2009).Studies like this should be taken to evaluate the present status of the environment so that the proper measures by the concerned authorities should be taken and policy making process should be in line with recommendation of such studies like planted trees as *Alstonia scholaris* should be a part of landscape avenues of any developing city as it prove its greater strength against the culminating pressure of pollution in Lahore city.

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