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TRAFFIC DENSITY, CLIMATIC CONDITIONS AND SEASONAL GROWTH OF *SAMANEA SAMAN* (Jacq.) Merr. ON DIFFERENT POLLUTED ROADS OF KARACHI CITY

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Abstract

A study was conducted during July 2008 to May 2009 to investigate the effects of traffic density and climatic conditions on the growth of *Samanea saman* (Jacq.) Merr., growing along different polluted roads of Karachi. Reduction in growth parameters such as leaf area, leaf fresh and dry weight, pods length, breadth, weight, seed length, breadth, weight and number of seeds per pod of *S. saman* were recorded at University Campus, University road, Board office road, Shaheed-e-millat road and Shahrah-e-Faisal during different seasons of the year. Some visual observations as canopy, fruit, seed production and leaf color were also recorded periodically which showed variation at different sites. Results indicated that *S. saman* at control site are growing as fast as they are given the favorable resources such as climatic factors which includes heat index, chill, humidity, temperature and wind speed available to them but road-side pollution stressed the growth. Climatic conditions were comparatively different on the city roads as compared to University Campus. The automobiles density has significantly ($p<0.05$) reduced the leaf area of *S. saman* at Shahrah-e-Faisal in summer season. This might be that during summer, growth was already slow, therefore the effects of pollutants on plants were more pronounced. These findings demonstrated that traffic density and harsh climatic conditions showed poor appearance and reduction in the reproductive parts and biomass of *S. saman.*

Introduction

The city of Karachi is characterized by high density of population and automobiles due to largest industrial activities. Karachi city is suffering by a series of environmental problems due to constant increase in population growth, automobiles activities, burning of solid waste, domestic fuel burning and industrial activities. Transport system in the city comprises on buses, minibuses, rickshaws, cars, trucks, motor cycles and locomotive trains. The traffic system in the city is not only noisy but also producing hazardous environmental effects on human and plants. Most of the automobiles emit black smoke due to incomplete combustion of fuel. Toxic materials such as carbon particles, unburned and partially burned hydrocarbons, fuels, tar materials, lead compounds and other elements which are the constituents of petrol and lubricating oils deposit on the surface of plants. These pollutants in combinations cause greater or synergistic effects to plants (Qadir & Iqbal, 1991). The uncontrolled growth in urbanization and motorization generally contributes to an urban land use and transportation system that is environmentally unsustainable (Qureshi & Huapu, 2007).

Samanea saman (Jacq.) Merrill belongs to the family Leguminosae and sub-family mimosoideae, commonly known as rain tree having 25 m height with rough bark and bipinnately compound, alternate leaves with four to seven pinnae. Each pinna bearing two to eight pairs of dark green leaflets of 1.5-6.0 cm length. Flowers seasonally, mostly in spring and summer; flowers many, borne in axillary, flat-topped heads. Corolla funnel-shaped, of five fused petals 7-12 mm long, pink with greenish or yellow tips, and many red stamens 2.0-3.5 cm long. Fruit a sausage-shaped pod 6-20 cm long with thickened seams (Whistler, 2000). *S. saman* occurs from near sea level to an elevation of 700 m, cultivated and sometimes abundantly naturalized along roadsides, on river banks and in forests (Smith, 1985).

Urban greening and urban forests are particularly critical to healthy cities in developing countries that contain some of the world's largest metropolitan areas. Urban green space that includes contiguous vegetated areas such as parks, forest stands, isolated trees growing along streets, in street medians, or on private property, is a critical foundation for both a healthy population and healthy economy in any city (Thaiutsa *et al.,* 2008). World Health Organization recommends at least 9 m^2 of urban green space per capita to mitigate a number of undesirable environmental effects and provide other benefits (Deloya, 1993). Different types of pollutants with varying nature had a wide range of ill effects on plants both quantitatively and qualitatively. The damage has been increased considerably from the last few years. The pollutants released from vehicular exhaust emission have brought changes in growth form of the plant species growing close to the busy roads of the city and could involve in the extinction of some important species. Excessive amount of toxic element usually caused reduction in plant growth (Prodgers & Inskeep, 1981). Roadside trees in the city are under pressure and are lost due to vehicular-traffic infrastructure and other community needs (Jim, 1998). Exhaust gas emissions from road traffic have been found to damage vegetation growing in the vicinity of roads and highways (Banerjee *et al*., 1983; Kammerbauer *et al.,* 1986; Sauter *et al.,* 1987). Adverse impacts of air pollution on vegetation around industrial sources and metropolitan cities have been reported by Iqbal *et al.,* 1994; Emberson, *et al.,* 2001; Shafiq & Iqbal., 2003; Shafiq *et al.,* 2009 etc. Lead treatments at 25 to 125µmolL^{-1} produced significant effect on shoot, root and seedling length of *Albizzia lebbeck* as reported by Farooqi *et al*., 2011. *Samanea saman* also showed reduction in seed germination and seedling growth due to toxicity when treated with different

concentration (25 to 100 ppm) of copper (Kabir *et al*., 2011). The Neem (*Azadirachta indica* A. Juss.) tree thus comes out to be capable of doing well under environmental stress and may, therefore, preferred for plantation in the polluted areas (Iqbal *et al.,* 2010). Plants not only have an ornamental function in urban areas, but they may also improve the quality of urban life (Akbari, 2002; Brack, 2002). Moreover, plants can uptake and accumulate pollutants through their roots and leaf surfaces (Sawdis *et al.,* 2001) in particular, leaves can act as biological absorbers of pollutants (Gratani *et al.,* 2000; Pal *et al.,* 2002).

Industrialization, urbanization, economic growth and associated increase in energy demands have resulted in a profound deterioration of urban air quality. Modernization and enhanced industrial activities led to the increased use of fossil fuels and their derivatives, particularly in developing countries (Karar & Gupta, 2006). Combustion emissions and their contribution to ambient particulate, semivolatile, and gaseous air pollutants all contain organic compounds and heavy metals that induce toxicity, mutagenicity, genetic damage, oxidative damage, and inflammation (Lewtas, 2007). Industrial area soil and vegetation showed variation due to discharge of various types of pollutants Kabir *et al*., (2010). The retention and presence of these pollutants in and surrounding the industries greatly decreased the habitat potential for flora of the region.

The aim of the present study was to investigate the effects of traffic density on qualitative and quantitative characteristic of *S. saman* growing in the polluted environment of Karachi city. Such studies may be helpful in selecting the tolerant species to pollutants which are capable to withstand the environmental stress and may therefore be introduced in the polluted areas.

Materials and Methods

The study sites selected were University Campus as Control while Board Office Road, University Road, Shaheed-e-Millat Road and Shahrah-e-Faisal as polluted roads. Traffic density of each road was recorded during different seasons. Number of different types of vehicles was observed for 6-hours per day as observations were divided into Morning, After-noon and Evening hours. Similarly climatic data of different roads for same hours were also recorded using the Kestrel 4000 NV Pocket Weather Tracker. Total number of vehicles per hour was recorded for different roads.

The plant materials influenced by the traffic emission were obtained from the road edge at a distance of 1-3 meters at the beginning of each season. Twenty five fresh leaf samples of *S. saman* were collected randomly from each area at 2-5 meters height through out the plant canopy to give respective average sample. Quantitative characters of the leaves such as leaf length, breadth, area and dry weights were recorded during different seasons. The fresh weight of leaves was taken and the samples were kept in an oven at 80 ^{0}C for 24 hours and oven dried weight of leaves was obtained by electrical balance. Similarly, twenty five samples of pods were collected from *S. saman* randomly. Quantitative characters of the pods such as pod length, pod breadth, pod weight with seeds, without seeds and seeds length, breadth, seed weights were also recorded during different seasons. All measurements were based on three replicates.

ANOVA test was applied to the data to determine the significance of differences between sample means; values obtained from differently polluted study sites are to be compared with the respective value from the reference site. The data obtained were also statistically analyzed by Duncan's Multiple Range Test using SPSS version 13.0 on personnel computer at $p<0.05$ level.

Results

Effects of traffic density of different polluted roads of Karachi city on visual characteristics and growth variables of *S. saman* were studied. Different vehicles, which contribute pollution were recorded on some selected roads. These vehicles include trucks, tankers, buses, mini buses, cars/pickup, rickshaws and motor cycles.

The number of vehicles was high on Shahrah-e-Faisal, recorded as 4011/h during the month of July 2008, 4169/h for the month of November, 2008 and 3957/h and 4304/h vehicles were recorded on the same Shahrah during February and May, 2009, respectively (Table 1). For other city roads there was significant ($p<0.05$) reduction in number of vehicle during different seasons of the year and this reduction of vehicles was more prominent for University Campus as compared to city roads. On the University road, high number of vehicles was recorded as compared to Board Office and Shaheed-e-Millat roads (Fig. 1). Data reveled that on Board Office road during the month of July, 3494/h vehicles were recorded which increased to 3598/h for the month of November, 2008 while, during February and May, 2009 the number of vehicles were 3321and 3316/h, respectively. Less traffic density was recorded at Shaheed-e-Millat road during July and November, 2008 and February and May, 2009 as compared to all other sites which indicated that it may be less polluted road as compared to other study roads of the city. During the same months, numbers of vehicles were also noted at the University Campus. Data recorded of different periods of the year showed that number of vehicles passed per hour on different city roads were high as compared to number of vehicles recorded at the University Campus.

Meteorology parameters during sampling periods were also determined. Climatic factors which include heat index, atmospheric humidity, chill, atmospheric temperature and wind speed were recorded during different seasons of the year showed that these parameters were higher for the month of July, 2008 and May, 2009 as compared to when they were recorded in November, 2008 and February, 2009. City roads showed high values for these climatic variables as compared to that which was recorded at the University Campus (Tables 2-4).

Table 1. Traffic density per hour at different roads of Karachi recorded during different seasons of the year 2008-2009.

Month	Sites	Trucks /Tankers	Buses	Mini-buses	Cars/ pick ups	Rickshaws	Motor cycles	Total
July, 2008	A	01	15	36	397	54	470	973
	B	4	28	456	1133	560	1669	3850
	C	9	42	487	1035	515	1406	3494
	D	9	2	391	816	246	1078	2542
	E	9	24	647	1826	213	1292	4011
November, 2008	A	-	12	11	348	20	295	686
	B	7	42	649	1093	331	1823	3945
	C	11	77	673	996	385	1456	3598
	D	10	1	336	765	176	1142	2430
	E	7	13	656	1915	191	1387	4169
February, 2009	A	2	14	16	336	35	213	616
	B	3	28	433	903	557	1730	3654
	C	6	32	467	956	404	1456	3321
	D	17	7	281	758	142	788	1993
	E	6	18	632	1783	125	1393	3957
May, 2009	A	2	3	3	364	36	428	836
	B	5	31	41	1265	495	1556	3393
	C	8	37	531	941	483	1316	3316
	D	6	12	411	852	271	1205	2757
	E	13	21	687	1903	243	1437	4304

Table 2. Climatic data in the morning hours (9:00-11:00am) along the roads of Karachi recorded during different seasons of the year 2008-2009.

Month	Sites	Heat index °C	Atmospheric humidity %	Chill °C	Atmospheric temperature °C	Wind speed m/s
July, 2008	A	33.1	71.0	28.5	28.3	0.8
	B	38.5	70.5	31.1	31.1	1.3
	C	37.1	63.3	31.3	31.2	1.5
	D	35.2	66.6	30.2	30.2	1.3
	E	42.4	61.5	33.6	33.6	1.3
November, 2008	A	34.1	70.2	29.1	28.8	1.1
	B	34.2	62.0	30.1	30.0	1.7
	C	33.8	63.1	29.8	29.7	0.9
	D	36.4	61.4	31.3	31.3	1.3
	E	35.4	58.7	31.4	31.5	1.0
February, 2009	A	32.8	52.5	30.6	32.4	1.9
	B	33.4	55.3	32.3	34.6	0.8
	C	29.0	29.3	29.7	29.6	1.0
	D	35.3	54.1	31.1	31.5	1.2
	E	34.6	59.7	30.6	37.7	1.7
May, 2009	A	35.3	68.8	27.5	27.6	0.6
	B	36.2	71.3	30.4	30.6	1.1
	C	36.8	64.6	29.8	29.8	1.5
	D	34.6	68.4	29.3	29.5	0.8
	E	38.7	62.3	32.5	32.3	1.2

Symbol used: A = University Campus, **B** = University Road, **C** = Board Office Road, **D** = Shaheed-e-Millat Road, **E** = Shahrah-e-Faisal

Table 3. Climatic data in the after noon hours (2:00-4:00pm) along the roads of Karachi recorded during different seasons of the year 2008-2009.

Month	Sites	Heat index °C	Atmospheric humidity %	Chill °C	Atmospheric temperature °C	Wind speed m/s
July, 2008	A	37.6	64.8	31.6	31.8	1.3
	B	40.7	68.4	32.6	32.7	1.9
	C	38.6	59.5	32.5	32.6	1.7
	D	39.9	55.6	33.3	33.3	2.0
	E	40.9	62.1	32.8	32.8	2.2
November, 2008	A	36.3	60.0	31.5	31.5	1.0
	B	38.1	55.6	32.7	32.7	1.2
	C	35.6	61.0	30.3	30.5	2.4
	D	33.7	34.0	33.3	33.4	1.4
	E	36.8	59.1	31.9	34.9	1.2
February, 2009	A	33.7	49.9	31.8	32.8	2.6
	B	29.8	58.5	27.8	27.8	2.7
	C	29.2	31.3	29.5	30.0	2.0
	D	35.0	52.3	31.4	31.5	1.1
	E	35.1	56.9	31.2	33.2	1.5
May, 2009	A	36.3	60.3	32.4	32.9	1.2
	B	39.5	61.1	33.1	34.2	1.6
	C	36.8	53.4	34.6	35.1	1.3
	D	37.1	49.6	35.2	36.1	1.9
	E	39.9	59.3	33.6	34.7	2.6

Table 4. Climatic data in the evening hours (5:00-7:00pm) along the roads of Karachi recorded during different seasons of the year 2008-2009.

Month	Sites	Heat index °C	Atmospheric humidity %	Chill °C	Atmospheric temperature °C	Wind speed m/s
July, 2008	A	37.7	68.6	30.6	30.5	1.2
	B	36.5	67.0	30.8	30.7	1.5
	C	36.2	64.4	31.0	31.1	1.6
	D	36.4	65.8	31.0	30.9	1.7
	E	38.8	64.2	31.6	31.8	1.7
November, 2008	A	35.4	61.4	30.7	30.7	1.2
	B	36.0	57.1	31.7	31.6	1.2
	C	32.0	60.3	29.3	29.3	1.7
	D	34.8	40.6	32.7	32.6	1.1
	E	34.9	60.2	30.7	31.7	2.1
February, 2009	A	31.2	51.6	30.0	29.8	2.4
	B	28.1	61.2	27.1	26.3	2.1
	C	28.2	34.1	28.6	28.5	1.3
	D	35.7	55.9	31.3	31.4	0.8
	E	32.8	64.0	29.4	29.5	1.6
May, 2009	A	34.2	70.2	31.4	32.2	1.9
	B	35.7	69.3	32.3	33.1	1.3
	C	36.9	67.5	33.8	34.6	1.5
	D	35.3	66.2	34.1	35.2	1.4
	E	37.2	68.0	32.4	33.1	1.2

Symbol used: A = University Campus, **B** = University Road, **C** = Board Office Road, **D** = Shaheed-e-Millat Road, **E** = Shahrah-e-Faisal

Fig. 1. Traffic density on different polluted roads of the city and University Campus recorded in 2009.
A = University Campus, B = University Road, C = Board Office Road, D = Shaheed-e-Millat Road E = Shahrah-e-Faisal

Fig. 2. *Samanea saman* growing on different roads of the city and university Campus
A = University Campus, B = University Road, C = Board Office Road, D = Shaheed-e-Millat Road, E = Shahrah-e-Faisal

Visual characteristics of plant species recorded during different seasons of the year on different roads showed diverse effects on growth of *S. saman*. Different parameters which include phenology, leaf area, leaf fresh and dry weight, pods size, number of seeds per pod, seed length and breadth of plants species were affected greatly by auto emission on Shahrah-e-Faisal as compared to other city roads and University Campus. *S. saman* showed its visual characteristics favored by environmental factors which were indicated by its thick canopy and dark green leaves (Fig. 2). It starts its flowering in May and seed production occurs during July. Fresh pods and seeds were present on plants when it was studied in July, 2008 on the University Campus, while process of pods and seed

production was slightly delayed on polluted road sites. Leaf color was dark green at University Campus while on road sites, green and dusty leaves were observed. Flower colour was recorded as whitish pink and more flowers were noted at University Campus and Shaheed-e-Millat road (Table 5). Fresh pods and seeds were observed in *S. saman* during July which exists even during November, 2008. Leaves of *S. saman* collected during July and November, 2008 from Shahrah-e-Faisal showed a significant ($p<0.05$) reduction in their leaf area. During July this species was observed with seed formation at the University Campus but on city road sites most of the plants were at flowering stage because of their reduced growth on city roads with increased level of pollution.

Table 5. Visual characteristics of *Samanea saman* observed at different roads of Karachi from July, 2008 to May, 2009.

Month	Sites	Canopy	Leaves	Flowers	Fruits
July, 2008	A	Dense	Dark green	Whitish pink and large in quantity	Fresh pods and seeds were present
	B	Thin and branched stem	Green	Whitish pink but less in quantity	Fresh pods and seeds were present
	C	Medium and branched	Green dusty	Whitish pink and less in quantity	Fresh pods and seeds were present
	D	Dense and branched stem	Dark green	Whitish pink and large in quantity	Fresh fruits and seeds were present
	E	Thin	Green and dusty	Whitish pink	Fresh pods and seeds were present
November, 2008	A	Dense	Dark green	Whitish pink but rarely present	Old pods and seeds were present
	B	Thin and branched stem	Dark green	Whitish pink but less in quantity	Old pods and seeds were present
	C	Medium and branched	Green dusty	Whitish pink and less in quantity	Old pods and seeds were present
	D	Dense and branched stem	Dusty green	Whitish pink and large in quantity	Old fruits and seeds were present
	E	Thin and branched	Green and dusty	Whitish pink	Old pods and seeds were present
February, 2009	A	Dense	Dark green	Flowers were absent	Pods and seeds were absent
	B	Thin and branched stem	Dark green	Flowers were absent	Pods and seeds were absent
	C	Medium and branched	Green dusty	Flowers were absent	Pods and seeds were absent
	D	Dense and branched stem.	Dusty green	Flowers were absent	Pods and seeds were absent
	E	Thin and branched	Green and dusty	Flowers were absent	Pods and seeds were absent
May, 2009	A	Dense	Dark green	Whitish pink and large in quantity	Fresh pods and seeds were present
	B	Thin and branched stem	Green	Initial flowers were more in quantity	Absent
	C	Dense and branched	Green dusty	Initial flowers	Absent
	D	Dense and branched stem	Dark green	Whitish pink and more in quantity	Fresh fruits and seeds were present
	E	Thin	Green and dusty	Initial flowers	Absent

Symbol used: A = University Campus, **B** = University Road, **C** = Board Office Road, **D** = Shaheed-e-Millat Road, **E** = Shahrah-e- Faisal

During July, 2008 leaf area of *S. saman* at the University Campus was determined as 9.53 sq cm which increased during November, 2008 up to 10.40 sq cm indicated that after flowering and seed production periods its growth is enhanced up to some extent due to rain in August and September-2008. On different polluted roads of city, low leaf area was found especially on Shahrah-e-Faisal as compared to University Campus. Leaf area at University road was 5.21 and 6.66 sq cm for the month of July and November, 2008, respectively while for February and May, 2009 it was recorded as 8.63 and 5.48 sq cm respectively. Low leaf area (4.86 sq cm) was found during July on Board Office road probably due to low atmospheric moisture contents which increased to 6.69 sq cm for the month of November, 2008 and 8.84 sq cm for February, 2009 while it decreased again for May, 2009 up to 5.71 sq cm. Same results were shown

by this species when observed on Shaheed-e-Millat road. Leaf dry weight indicated that low dry weight was recorded during the month of July at all the city and University Campus as compared to November, 2008 and February and May, 2009 (Table 6). *S. saman* pods and seed length was also declined in polluted roads of the city as compared to University Campus (Tables 7 and 8). During July, 2008 more reduction was recorded in pods and seed lengths, pods and seed weight as compared to pods and seed concerned parameters recorded in November, 2008. Results indicated that on the polluted roads, plant growth was significantly ($p<0.05$) inhibited by vehicular emission.

Discussion

In this study we investigated the effects of traffic density and climatic conditions on *S. saman* using leaf and reproductive materials collected from the polluted and less polluted sites of the city. The effects of traffic density and climatic conditions on *S. saman* varied from site to site. Emissions from auto exhaust have a detrimental effect on plants growing in the area. Developing regions often face critical air pollution problems due to the rapid growth of transportation and industry sources (Bell *et al.,* 2006). The study suggested that increase in global temperature as a result of climate change may worsen the harmful effects of pollution on plant diversity. Most of the growth parameters were enhanced during February showing that climatic factors are also important for increase or decrease of growth along with pollution which normally suppressed the growth of most plant species. Better growth and productivity during spring season is commonly observed due to the influence of environmental variables (Baydar & Erbas, 2005). Longer photoperiod (16 h) accelerated the plant development such as seed germination, initiation and growth pattern of leaves and floral bud induction (Connor & Sadras, 1992). Temperature is an important climatic attribute affecting leaf emergence, leaf area and plant height (Kaleem *et al.,* 2009). Any change in ambient climate strongly influences the morphological and quantitative variables including plant height, head diameter, achene number per head, achene weight and oil contents in sunflower (Killi *et al*., 2005). Plants grown at two different environments showed differences in shoot growth rate (Hendrickson *et al*., 2004).

Table 6. Effects of auto emission on leaf area and dry weight of *Samanea saman* at different roads of Karachi during July, November, 2008, February and May, 2009.

Sites	July, 2008			November, 2008		
	Leaf area (sq cm)	Leaf fresh wt. (mg)	Leaf dry wt. (mg)	Leaf area (sq cm)	Leaf fresh wt. (mg)	Leaf dry wt. (mg)
A	9.53 ± 1.07a	170 ± 7.76a	77.70 ± 7.71a	10.40 ± 0.13a	164 ± 7.26a	86.68 ± 7.10a
B	5.21 ± 0.19b	136 ± 1.73b	43.94 ± 3.21b	6.66 ± 0.07bc	138 ± 3.75bc	50.52 ± 2.01b
C	4.86 ± 0.37b	141 ± 1.52b	47.95 ± 1.66b	6.69 ± 0.39bc	145 ± 1.45bc	53.26 ± 1.64b
D	5.86 ± 0.85b	149 ± 2.96b	49.27 ± 6.48b	7.50 ± 0.29b	152 ± 4.37ab	54.46 ± 7.06b
E	4.60 ± 0.23b	135 ± 3.75b	40.22 ± 3.00b	5.93 ± 0.41c	132 ± 4.05c	47.18 ± 2.45b
Sites	**February, 2009**			**May, 2009**		
	Leaf area (sq cm)	Leaf fresh wt. (mg)	Leaf dry wt. (mg)	Leaf area (sq cm)	Leaf fresh wt. (mg)	Leaf dry wt. (mg)
A	10.9 ± 0.17a	169 ± 8.11a	73.33 ± 2.96a	9.02 ± 0.23a	155 ± 7.00a	79 ± 4.41a
B	8.63 ± 0.34b	133 ± 3.52b	61.66 ± 1.45b	5.48 ± 0.33c	100 ± 4.97c	54 ± 2.33c
C	8.84 ± 0.10b	134 ± 1.33b	61.66 ± 2.73b	5.71 ± 0.31c	121 ± 2.90b	73 ± 2.73ab
D	9.16 ± 0.13b	136 ± 2.31b	64.00 ± 0.57b	7.55 ± 0.28b	134 ± 4.48b	67 ± 2.64b
E	7.06 ± 0.38c	129 ± 3.52b	59.00 ± 2.00b	4.93 ± 0.09c	82 ± 5.03d	46 ± 2.33c

Table 7. Effects of auto emission on pod and seed of *Smanea saman* at different roads of Karachi during July, 2008.

Sites	Pod length (cm)	Pod breadth (cm)	Seed length (cm)	Seed breadth (cm)	Pod wt. with seeds (g)	Pod wt. with out seeds (g)	No. of seeds/pod	Seed weight (g)
A	22.13 ± 0.84a	2.03±0.06a	1.06±0.03a	0.76±0.03a	19.67±0.42a	16.07±0.34a	20±0.33a	0.18±0.01a
B	18.40 ± 0.43c	1.73±0.03c	0.86±0.03cd	0.56±0.03c	16.40±0.28b	13.80±0.28b	17±0.33b	0.15±0.01b
C	19.53 ± 0.49bc	1.76±0.03bc	0.93±0.03bc	0.63±0.03bc	17.21±0.47b	14.60±0.40b	18±0.58b	0.16±0.01b
D	21.13 ± 0.38ab	1.90±0.06ab	1.00±0.06ab	0.73±0.03ab	19.44±0.11a	15.95±0.13a	19±0.00a	0.18±0.01a
E	16.10±0.15d	1.63±0.03c	0.76±0.03d	0.56±0.03c	15.21±0.06c	12.93±0.03c	16±0.33b	0.13±0.01c

Table 8. Effects of auto emission on pod and seed of *Samanea saman* at different roads of Karachi during November, 2008.

Sites	Pod length (cm)	Pod breadth (cm)	Seed length (cm)	Seed breadth (cm)	Pod wt. with seeds (g)	Pod wt. with out seeds (g)	No. of seeds/pod	Seed weight (g)
A	20.96±0.63a	1.96±0.09a	0.90±0.06a	0.66±0.03a	19.16±0.09a	16.09±0.29a	18±0.58a	0.17±0.01a
B	17.66±0.41b	1.60±0.00bc	0.70±0.00b	0.46±0.03bc	15.89±0.28bc	13.59±0.26bc	16±0.58c	0.14±0.01b
C	18.53±0.56b	1.63±0.03bc	0.80±0.06ab	0.56±0.03ab	16.78±0.56b	14.53±0.56b	16±0.33bc	0.14±0.00b
D	20.63±0.28a	1.73±0.03b	0.83±0.03ab	0.63±0.03a	18.57±0.34a	15.68±0.33a	17±0.33ab	0.16±0.01a
E	15.66±0.23c	1.50±0.06c	0.70±0.58b	0.43±0.03c	15.04±0.03c	12.96±0.03c	15±0.33c	0.13±0.00b

Number followed by the same letters in the same column are not significantly different according to Duncan Multiple Range Test at $p<0.05$ level, ± Standard Error

Symbol used: **A** = University Campus, **B** = University Road, **C** = Board Office Road, **D** = Shaheed-e-Millat Road, **E** = Shahrah-e- Faisal

Increased levels of pollutants caused a decline in species richness. However, the effects are also depending on the type of polluters and the plant species. The present findings are supported by Hussain *et al*., (1989) and Shah *et al*., (1991), who observed that road side plants generally grow unhealthy. In addition, warmer and more humid climatic conditions may intensify the mobility and toxicity of the pollutants. One of fundamental effects may be changes in plant phenology which is indicated by interactions between temperature and photoperiod (Bale *et al*., 2002).

Plant phenology is dependent upon environmental factors (Pillai *et al*., 1995). Higher temperature not only promotes but also hastens germination (Khalifa *et al*., 2000). So phenology is an easily observed trait that responds to climate change and allows us to predict vegetation adjustments and future tendencies in ecosystems in response to climate change by environmental pollution (Penuelas & Filella 2001; Badeck *et al*., 2004). The plants growing adjacent to roadsides of the city exhibited considerable damage in response to automobile exhaust emission (Iqbal & Shafiq, 1999; Shafiq & Iqbal, 2005). Of all the plant parts, the leaf is the most sensitive part to be affected by air pollutants. The sensitivity rests on the fact that the major portions of the important physiological processes are concentrated in the leaf. Therefore, the leaf at its various stages of development, serves as a good indicator to air pollutants (Shafiq *et al*., 2009). Pollutants derived from the autoemission can directly affect the foliage of plants by entering the leaf, destroying individual cells, and reducing the plant ability to produce food. Reduction in leaf length, width and leaf area of roadside plants was the witness of ill effects of the city environment. It was found that the plants growing on the Shahrah-e-Faisal are highly affected by autoemission. The inhibitory effects on the growth of plants are due to the presence of toxic material in the autoemission. The air pollution interferes with the seasonal variations, which takes place in plants. Time of flowering, senescence, shed of fruit, maturation of fruits and emergence of new leaves, all these processes are disturbed by air pollution (Bhatti & Iqbal, 1988).

A major source of air pollution in urban areas is the combustion of diesel and gasoline fuels in cars, buses, trucks and other on-road transportation sources (Anon., 2004). The presence of various types of pollutants derived from automobiles might be responsible for the reduction in leaf dry weight of *S. saman*. Less leaf dry

mass of all the plants at Shahrah-e-Faisal might be due to carbon exchange becomes limited and hence photosynthesis reduced. Therefore, reduction in leaf fresh and dry weight is directly related to different types of pollutants which are released into the environment by auto exhaust. The leaf areas, leaf dry and fresh weights of polluted road side plants were greatly reduced. Our finding agree with those of Sibak & Gulyas (1990); Iqbal & Shafiq (2001) and Shafiq & Iqbal (2003, 2005) who reported reduced leaf size due to air borne pollutants derived from automobiles. The productivity of a plant mostly depends on the rate of photosynthesis and respiration but on Shahrah-e-Faisal all these processes were disturbed which resulted in reduction of growth and biomass production. Even in areas where pollutant emissions are within the limits set by legislation, the study suggests that these contaminants could become more harmful to plant communities as the climate warms and changes (Zvereva *et al*., 2008). There is a need to draw a special attention on the protection of the environment by all segments of the society on urgent basis. Our efforts can be fruitful for healthy environment by making an effective policy and sharing the experiences of environmental friendly organizations working in developed countries of the world.

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