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Investigations into the effect of automobile exhausts on the phenology, periodicity and productivity of some roadside trees

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Abstract

In response to a polluted atmosphere, the phenology of *Ficus bengalensis* and *Eucalyptus* sp. was highly affected. The yield of seeds and fruits of *Guaiacum officinale* and *Azadirachta indica* was lessened at the polluted sites. The automobile emissions significantly reduced the productivity in *G. officinale*, *F. bengalensis* and *Eucalyptus* sp., whereas, *A. indica* was comparatively resistant to vehicle exhaust pollution. Leaf area and dry weight were significantly reduced in most of the plants.

Key words: *automobile exhaust*, *periodicity*, *phenology*, *productivity*, *seasonal effects*, *trees*

INTRODUCTION

Karachi is the most industrialized and the largest city in Pakistan. The city centre sufferes from heavy traffic pollution. A survey report of PCSIR (1982 – unpublished) showed that the concentration of smoke at M. A. Jinnah Road was recorded as 100-200 kg m^{-3} whereas the CO_2 concentration was 10.15 ppm.

Prindle and Charles (1962) described the damage caused to animals and agricultural crops by automobile emission. Darley et al. (1963) noticed the damaging effects of gases and different compounds present in motor vehicle exhaust on the leaves of a variety of crop plants.

MATERIAL AND METHODS

For the study of automobile pollution effects on plants, four sites (University Campus (control), Hasan Square, Tariq Road, Grumander) in the city were selected. At each site four trees (*Guaiacum officinale* L., *Ficus bengalensis* L., *Eucalyptus* sp., *Azadirachta indica*) were choosen based on uniform height, DBH (diameter breast height). Quantitative characters were recorded during four seasons (December-January 1985-1986, March-April 1986, May-June 1986 and July-August 1986). All the recordings were based on three replications. Fresh leaves were collected at a uniform height. Leaf length, area and oven dry weights were recorded. The data was analysed by analysis of variance technique and Student-Newman-Keuls multiple range test.

RESULTS

In most of the cases, leaf length, area and dry weight were significantly reduced at the highly polluted areas i.e. Grumander and Tariq Road as compared to less polluted sites (Table 1).

During winter (December-January 1985-1986), the leaf length, area and dry weight in almost all the species studied were less at Grumander when compared with other stations (Table 1). At the control site (Campus), all the parameters were found to be higher. The leaf area and dry weight of *G. officinale* were significantly less ($p < 0.05$) at Grumander as compared to the control (Table 1). Whereas, the leaf area of *F. bengalensis* was significantly less ($p < 0.05$) at Hasan Square and Grumander in comparison to Campus.

During March-April 1986, the leaf length, area and dry weight of *G. officinale* and *Eucalyptus* sp. were reduced significantly ($p < 0.05$) at Grumander as compared to control, while in *A. indica*, only the leaf dry weight was significantly less ($p < 0.05$).

During May-June 1986, leaf length, area and dry weight in *F. bengalensis* were less at Grumander then in other areas. In the case of *G. officinale* and *Eucalyptus* sp., all the measured variables were significantly reduced ($p < 0.05$) at Grumander as compared to Campus area. Similarly, leaf length and dry weight of *A. indica* and leaf dry weight of *F. bengalensis* were significantly less ($p < 0.05$) at Grumander in comparison with the control.

In July-August 1986, *F. bengalansis* showed reduction in leaf length, area and dry weight at Grumander as compared with other sites. *G. officinale* and *Eucalyptus* sp. showed reduction in leaf variables mostly at Grumander. However leaf length of *G. officinale* and leaf area in *Eucalyptus* sp. were reduced at Hasan Square and Tariq Road, respectively. On the other hand, leaf length and area of *A. indica* at Tariq Road and leaf dry weight at Grumander were less as compared to other stations.

Seasonal effects of automobile pollution on the size, area and dry weight of leaves of roadside trees growing at different areas in the city

Species	Stations	December-January 1985-1986			March-April 1986			May-June 1986			July-August 1986		
		leaf length (cm)	leaf area (cm^2)	leaf dry wt. (mg)	leaf length (cm)	leaf area cm^2)	leaf dry wt. (mg)	leaf length (cm)	leaf area (cm^2)	leaf dry wt. (mg)	leaf length (cm)	leaf area (cm^2)	leaf dry wt. (mg)
G. officinale	I	a 3.55±0.03	a 23.22±0.19	ab 1.36 - 0.18	a 3.41±0.07	a 5.74±0.26	a 0.5 ±0.0	a 3.2 ±0.11	a 7.61±0.13	a 0.33±0.01	a 3.44±0.11	a 9.16±0.64	6.62±0.05
	II	a 3.60±0.12	c 17.16±0.45	b 0.74±0.15	bd 1.6 ±0.01	bd 1.61±0.06	b 0.21±0.0	cd 2.82±0.06	cd 2.84±0.19	cd 0.27±0.02	bd 2.45±0.15	bd 3.41±0.32	bd 0.23±0.04
	III	a 3.55±0.14	c 18.32±0.26	b 0.8 ±0.21	b 1.67±0.07	b 1.61±0.06	c 0.27±0.0	c 2.66±0.10	c 2.77±0.64	bc 0.17±0.01	ba 2.92±0.27	bc 6.83±0.25	cd 0.4 ±0.04
	IV	a 3.48±0.10	b 15.74±1.81	bc 0.39±0.02	b 1.64±0.09	b 1.16±0.13	d 0.08±0.0	b 2.2 ±0.06	b 2.00±0.64	bd 0.19±0.02	bd 2.5 ±0.11	b 2.16±0.19	b 0.21±0.02
F. bengalensis	I	a 8.49±0.38	a 104.72±2.26	a 24.22±3.08	a 13.26±0.52	a 137.94±2.45	a 11.47±0.4	a 14.5 ±0.04	a 127.43±1.10	a 7.24±0.21	a 16.3 ±0.47	a 157.29±2.51	a 14.2±0.69
	II	a 7.96±0.18	d 96.84±2.32	a 26.64±3.17	a 13.22±0.02	a 92.91±5.87	a 10.37±0.52	a 12.89±1.27	a 67.36±10.32	cd 5.03±0.56	ab 14.01±0.75	cd 73.42±8.71	a 12.21±0.49
	III	a 8.11±0.18	ad 97.43±0.58	a 21.57±2.15	a 13.23±0.0	a 104.20±0.90	a 9.32±0.66	a 13.19±0.39	a 70.07±4.81	bc 5.1 ±0.16	ab 13.85±1.05	cd 79.29±5.8	a 13.05±0.87
	IV	a 8.27±0.31	b 87.30±3.55	a 20.59±3.81	a 12.41±0.09	a 105.04±0.32	a 10.64±0.51	a 10.16±1.29	a 50.13±12.97	bd 3.44±0.84	b 10.6 ±0.75	cb 56.00±8.45	b 9.78±0.23
Eucalyptus sp.	I	a 3.57±0.28	a 106.46±2.45	a 4.92±0.51	a 18.8±0.55	a 45.74±2.52	a 6.41±0.07	a 18.9 ±0.71	a 41.16±0.19	a 6.37±0.12	a 17.35±0.59	a 39.67±3.09	a 5.3 ±0.26
	II	a 3.07±0.10	a 95.55±1.55	a 3.63±0.24	ad 14.91±0.37	ad 37.55±1.35	b 4.74±0.25	ad 15.24±0.61	ad 30.91±0.32	ad 1.81±0.05	d 14.36±0.59	cd 30.77±0.51	bd 3.69±0.23
	III	a 2.70±0.18	a 86.65±1.87	a 3.81±0.4	bc 14.8 ±0.38	bc 35.23±1.29	c 4.13±0.05	cd 15.09±0.95	cb 28.52±1.10	ab 2.02±0.18	bc 14.72±0.83	c 28.51±1.61	bc 3.4 ±0.3
	IV	a 2.43±0.13	a 66.20±1.74	a 3.58±0.16	bd 13.42±1.2	bd 34.00±3.74	d 2.25±0.08	b 12.78±0.64	db 30.26±3.03	db 1.85±0.1	b 12.09±0.36	ac 31.93±2.00	b 3.23±0.25
A. indica	I	a 7.12±0.13	a 95.42±0.52	a 1.55±0.17	a 6.66±0.52	a 12.19±0.9	a 1.66±0.27	a 6.63±0.26	a 16.13±0.71	a 0.75±0.01	a 8.07±0.09	a 14.83±0.58	a 2.97±0.16
	II	a 7.0 ±0.08	a 42.26±0.26	a 1.29±0.5	a 6.04±-.06	a 9.48±1.23	a 1.5±0.16	cd 6.35±0.26	a 9.87±1.48	cd 0.37±0.02	bd 6.51±0.14	cd 8.71±0.12	a 3.52±0.13
	III	a 6.79±0.32	a 38.07±0.45	a 1.09±0.29	a 6.16±0.08	a 8.32±0.39	a 1.56±0.16	cb 6.37±0.05	a 9.87±0.9	cb 0.38±0.02	bc 6.32±0.31	cd 8.58±0.77	a 2.89±0.28
	IV	a 6.94±0.14	a 43.10±3.03	a 1.05±0.08	a 5.75±0.07	a 10.00±0.52	b 0.32±0.0	db 6.27±0.27	a 11.10±1.29	db 0.39±0.01	b 6.4 ±0.26	cb 8.64±0.32	a 2.83±0.24

Stations: I – University Campus; II – Hasan Square; III – Tariq Road, IV – Grumander.

Statistical significance determined by analysis of variance. Number followed by the same letters in the same column for same species are not significantly different ($p < 0.05$) according to the Student-Newman-Keuls Multiple range tests. ± Standard error.

DISCUSSION

It was observed that in most of the cases, plants were more severely affected at Grumander than at the other study areas. According to the K. D. A. Traffic Engineering Bureau report of 1986 (unpublished), the density of vehicles was greater at this point as compared to other points in the city. The density of vehicles was also high on the roads which join M. A. Jinnah Road at Grumander. It was shown that in the polluted city centre the temperature was higher, light intensity was lower (Shams and Iqbal 1986). At the polluted areas rate of photosynthesis, assimilation and reasonable transpiration are disturbed which results in reduction of tree growth and biomass production. The plants also showed less production of fruits and flowers, reduction in chlorophyll and completely clogged stomates (Ahmad and Qadir 1975). Reduced yields of flowers, fruits and seeds have also been demonstrated by Heagle et al. (1976). Air pollution inhibits many metabolic processes of plants (Treshaw 1975). Ozone affects protein metabolism either by enhancing protein hydrolysis resulting in an increase of free amino acids or by interfering in protein synthesis (Pestka 1971). Automobile pollutants have also been shown to modify amino acids (Ismail and Ahmed 1984). Air pollution interferes with time of flowering, fruiting, senescene, shedding of fruits and the emergence of leaves. Early maturation and fall-off of fruits occurred at the polluted sites as compared to the clean area. *G. officinale*, which is mostly grown in the centre of many roads in Karachi, did not show any visible injury but its productivity was much reduced at the polluted sites. *F. bengalensis*, which has broader leaves, showed more visible injury than with smaller and narrow leaves, as are found in *A. indica*. It is therefore, suggested that *A. indica* should be planted along the roadsides.

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Badanie wpływu spalin samochodowych na fenologię, okresowość i produkcyjność niektórych drzew przydrożnych

Streszczenie

Zanieczyszczone powietrze wywarło znaczny wpływ na fenologię *Ficus bengalensis* i *Eucalyptus* sp. Zbiór nasion i owoców *Guaiacum officinale* i *Azadirachta indica* był mniejszy na miejscach zanieczyszczonych. Spaliny samochodowe wyraźnie zmniejszyły produkcyjność *G. officinale*, *F. bengalensis* and *Eucalyptus* sp., Podczas gdy *A. indica* była stosunkowo odporna na zanieczyszczenia spalinami. U większości roślin powierzchnia liści i ich sucha masa były wyraźnie mniejsze.