Effects of Environmental Pollution (Auto-Exhaust) on the Micro-Morphology of Some Ornamental Plants from Sudan

Abdulmoniem M.A. Saadabi and Al-Nur El-Amin
Department of Microbiology and Microbial Technology,
Faculty of Science and Technology, Al-Neelain University, Khartoum, Sudan

Abstract: Ten ornamental plants belonging to different families from five sites in Khartoum the capital city of Sudan with equivalent environmental pollution were selected to determine the effect of auto-exhaust pollution on their micro morphological traits. The parameters utilized were numbers of stomata/unit area, numbers of epidermal cells/unit area, length and width of stomata, stomata calculated area, L/B ratio of stomata and stomatal indices from upper and lower surface of the fixed leaf which were found distinctive for each locality.

Key words: Auto-exhaust, pollution, ornamental plants, Khartoum city, Sudan

INTRODUCTION

It is well known that environmental conditions affect plant micro morphology (Halloy and Mark, 1996; Orshan, 1986; Meinder and Mansfield, 1968; Fahn, 1967). The impact of environmental pollution on plants is well documented (Solberg and Adams, 1956; Heggstad, 1968; Feder, 1970; Heck *et al.*, 1973; Mukammal, 1976; Guderian, 1977). For most plants leaves usually perform basic functions such as capture of light energy and carbon molecules (Halloy and Mark, 1996).

These functions can best be fulfilled by flat, thin leaf surface full of chlorophyll (Cooper *et al.*, 1993) Leaf micro morphology has often been interpreted as a sensitive indicator of environmental pollution. Although, there is paucity of information on the effect of environmental pollution on the epidermal features of the plant leaves (Bondada *et al.*, 2006), the research in this field is probably recent or it is still unpublished. However, Singh *et al.* (1995), Sharma and Tyree (1973), Sharma and Butter (1975), Garg and Varshney (1980), Weyers and Travis (1981) reported a decrease in the size of stomatal opening and an increase in the frequency of epidermal cells and stomata in response to environmental pollution in some plant taxa. Interest in growing ornamentals is increasing as a profitable business.

They have many desirable qualities such as color, texture, shapes and planting patterns. The cut flowers and flowering plants in general are being used widely for family and outdoor gardens as well as for decoration purposes. Because many of these plants are grown along the roadsides and highways and the absence of strict disease control as well as exhaust pollution may affect these plants, most people do not look upon ornamentals as being of economic importance. Therefore, the present

research was designed for the first time to evaluate the effect of auto-exhaust pollution which constitutes 50-60% of the air pollution in urban environment on morphological and leaf epidermal features of some ornamental plants from Khartoum, the capital city of Sudan.

MATERIALS AND METHODS

The research was conducted in the Department of Microbiology and Molecular Biology, Faculty of Science and Technology, Al Neelain University, Sudan during 2007-2008. Maximum attention was given for the collection of ornamentals which were closer to the traffic pathway getting direct contact to auto-exhaust. Fresh collections were made from five sites in the industrial area of Khartoum city where the auto-exhaust air pollution is present. For comparison, collections were done also from a relatively clean area of Khartoum such as Al-Mogran garden which was considered as control on the same day at fixed time. A single leaf proved to be the fully developed youngest leaf per plant species was fixed using F.A.A (Formaldehyde 5%, Acetic acid 5% and Ethanol alcohol 90%).

The ornamental plants investigated were: *Argyrea nervosa* Bojer (Convolvulaceae), *Aristolochia elegans* Mast. (Aristolochiaceae), *Barleria calophylla* Lindau (Acanthaceae), *Bauhinia candida* Act. (Caesalpinaceae), *Begonia elatior* Hort. (Begoniaceae), *Caladium hortulanum* Birdsey (Araceae), *Canna indica* L. (Cannaceae), *Eulophia quartiniana* A. Rich (Orchidaceae), *Euphorbia trigona* Haw (Euphorbiaceae) and *Nerium oleander* L. (Apocynaceae). The fixed leaf (5th leaf) was taken and washed in distilled water carefully. The upper and lower peelings were carefully

taken with extra care mounted in lactophenol-cotton blue and examined under compound microscope using 10x ocular and 40x objective. CuSO₄ treatment and nail polish impression methods were also performed (Dickison, 2000) where peeling removal was hardly possible and ten observations were made per parameter. For measuring the length and breadth of stomata ocular micrometer of 10 µm least count was used and for counting the number of stomata and epidermal cells a diaphragm eyepiece of unit area (3600 µm²) was taken or sometimes a haemocytometer (1×1 mm grid) (Meinder and Mansfield, 1968) was also used. Stomatal index was determined by Salisbury (1927) equation:

$$S.I. = \frac{S \times 100}{S + E}$$

where, S.I. is Stomatal Index; S is Number of stomata/unit area and E is Number of epidermal cells/unit area.

Data analyses: Data obtained were pooled and the means were used in analysis for significant differences using appropriate procedure (SAS Institute Inc., Cary, NC, USA).

RESULTS AND DISCUSSION

The auto-exhaust-polluted ornamentals grown on the roadside at Khartoum city showed unthriftness with erea. severe retardation and obvious chloroses. These observations show how much the auto-exhaust pollution at the city affects plants at different percentages on each of the parameters of micro morphology (Table 1-4).

Table 1: Effect of autoexhaust pollution at Khartoum city on the micromorphology of some ornamentals in the upper surface of the leaf (Values are means±SD of 10 observations/parameter)

Plant species (Botanical family)	Location	Number of stomata/unit area (3600 µm ²)	Number of epidermal cells/unit area (3600 µm ²)	Stomatal index
<i>Argyrea nervosa</i> Bojer (Convolvulaceae)	Control	1.22±0.310	3.27±0.76	19.20±3.11
	Polluted	2.00±0.440***	5.75±2.90	16.00±5.15
<i>Aristolochia elegans</i> Mast. (Aristolochiaceae)	Control	1.20±0.40	5.87±0.48	20.86±4.67
	Polluted	1.65±0.60***	6.81±0.99***	19.27±6.66
<i>Barleria calophylla</i> Lindau (Acanthaceae)	Control	1.29±0.46	4.87±0.75	21.36±8.90
	Polluted	1.29±0.46	6.56±3.89**	26.47±5.90
<i>Bauhinia candida</i> Act. (Caesalpiniaceae)	Control	1.29±0.46	3.57±0.99	23.16±7.07
	Polluted	1.55±0.51*	6.00±0.52***	34.81±8.60
<i>Begonia elatior</i> Hort. (Begoniaceae)	Control	1.15±0.320	8.67±1.09	14.86±4.27
	Polluted	1.33±0.49***	8.67±1.11	16.57±4.30
<i>Caladium hortulanum</i> Birdsey (Araceae)	Control	1.35±0.46	3.87±0.69	24.86±8.47
	Polluted	1.55±0.79***	5.56±0.89***	31.87±7.60
<i>Canna indica</i> L. (Cannaceae)	Control	1.20±0.41	7.60±0.96	22.16±7.17
	Polluted	1.65±0.79***	9.20±2.09***	32.35±13.17
<i>Eulophia quartiniiana</i> A. Rich (Orchidaceae)	Control	1.40±0.15	3.57±0.89	18.56±3.97
	Polluted	1.41±0.05	5.60±0.89***	21.80±7.04
<i>Euphorbia trigona</i> Haw. (Euphorbiaceae)	Control	1.11±1.160	5.37±0.70	20.26±8.70
	Polluted	1.32±0.060	6.16±2.99	05.17±4.14
<i>Nerium oleander</i> L. (Apocynaceae)	Control	1.20±0.41	6.87±1.40	21.36±8.90
	Polluted	2.11±0.84***	9.56±3.53**	26.47±5.90

* = Significant at p<0.1% level, ** = Significant at p<0.05% level, *** = Significant at p<0.01% level

Table 2: Effect of autoexhaust pollution at Khartoum city on the micromorphology of some ornamentals in the upper surface of the leaf (Values are means±SD of 10 observations/parameter)

Plant species (Botanical family)	Location	Length of stomata (L) (µm)	Breadth of stomata (B) (µm)	L/B ratio	Calculated area of stomata (µm ²)
<i>Argyrea nervosa</i> Bojer (Convolvulaceae)	Control	28.44±1.25	3.21±0.29	8.85±2.45	91.29±17.03
	Polluted	20.18±2.00***	2.14±0.44***	9.42±0.00	43.18±11.80
<i>Aristolochia elegans</i> Mast. (Aristolochiaceae)	Control	42.36±2.30	3.65±0.46	11.60±1.30	154.61±16.13
	Polluted	27.33±3.42***	2.99±0.39***	9.14±2.56	81.71±18.44
<i>Barleria calophylla</i> Lindau (Acanthaceae)	Control	13.33±1.65	4.47±0.39	3.00±1.05	59.58±13.01
	Polluted	10.66±0.74***	2.50±0.44***	5.20±1.45	21.85±2.500
<i>Bauhinia candida</i> Act. (Caesalpiniaceae)	Control	22.18±2.80	5.44±0.63	4.07±0.88	120.65±15.39
	Polluted	20.00±2.75	5.13±0.66***	3.89±0.74***	102.60±16.57
<i>Begonia elatior</i> Hort. (Begoniaceae)	Control	16.11±3.55	4.80±0.68	3.35±1.73	77.32±18.16
	Polluted	15.95±3.50	2.98±0.37***	5.35±2.60**	47.53±16.21
<i>Caladium hortulanum</i> Birdsey (Araceae)	Control	20.41±4.260	5.60±1.40	3.64±1.60	114.29±16.00
	Polluted	13.94±4.13***	6.00±2.00	2.30±1.45	83.64±20.00
<i>Canna indica</i> L. (Cannaceae)	Control	25.91±2.88	4.35±1.22	5.95±1.00	112.70±16.00
	Polluted	19.64±0.77***	3.38±0.87***	5.81±1.13	66.38±12.00
<i>Eulophia quartiniiana</i> A. Rich (Orchidaceae)	Control	14.77±0.74	4.50±0.98	3.19±0.75	66.46±11.50
	Polluted	6.14±1.88***	3.00±1.23***	2.04±1.75	18.42±2.500
<i>Euphorbia trigona</i> Haw. (Euphorbiaceae)	Control	14.18±1.75	5.15±1.34	2.75±1.40	73.02±19.22
	Polluted	10.77±1.88	2.80±0.39***	3.84±1.04	30.15±6.930
<i>Nerium oleander</i> L. (Apocynaceae)	Control	30.11±2.25	4.80±0.88	6.27±1.37	144.52±14.66
	Polluted	26.24±2.22***	2.95±0.46***	8.89±2.81	77.40±16.37

** = Significant at p<0.05% level, *** = Significant at p<0.01% level

Table 3: Effect of autoexhaust pollution at Khartoum city on the micromorphology of some ornamentals in the lower surface of the leaf (Values are means $\pm$ SD of 10 observations/parameter)

Plant species (Botanical family)	Area	Lower surface		
		No. of stomata/unit area (3600 μm^2)	No. of epidermal cells/unit area (3600 μm^2)	Stomatal index
<i>Argyrea nervosa</i> Bojer (Convolvulaceae)	Control	1.33 $\pm$ 0.41	4.22 $\pm$ 0.83	22.00 $\pm$ 3.60
	Polluted	2.60 $\pm$ 0.18***	7.14 $\pm$ 3.00**	25.09 $\pm$ 6.360
<i>Aristolochia elegans</i> Mast. (Aristolochiaceae)	Control	1.44 $\pm$ 0.32	6.11 $\pm$ 0.49	22.46 $\pm$ 3.93
	Polluted	1.88 $\pm$ 0.63***	8.37 $\pm$ 0.90**	23.67 $\pm$ 5.140
<i>Barleria calophylla</i> Lindau (Acanthaceae)	Control	1.37 $\pm$ 0.52	5.00 $\pm$ 0.88	22.46 $\pm$ 7.50
	Polluted	1.40 $\pm$ 0.43	7.00 $\pm$ 2.99***	28.27 $\pm$ 5.400
<i>Bauhinia candida</i> Act. (Caesalpiniaceae)	Control	1.43 $\pm$ 0.41	4.11 $\pm$ 0.80	24.26 $\pm$ 6.08
	Polluted	2.11 $\pm$ 0.24*	7.55 $\pm$ 0.51**	36.81 $\pm$ 9.300
<i>Begonia elatior</i> Hort. (Begoniaceae)	Control	1.90 $\pm$ 0.22	9.90 $\pm$ 1.90	18.22 $\pm$ 3.66
	Polluted	2.00 $\pm$ 0.50***	10.80 $\pm$ 1.50	20.11 $\pm$ 4.110
<i>Caladium hortulanum</i> Birdsey (Araceae)	Control	1.60 $\pm$ 0.72	4.00 $\pm$ 0.81	26.11 $\pm$ 3.42
	Polluted	2.50 $\pm$ 0.01	6.00 $\pm$ 0.86***	34.18 $\pm$ 6.00
<i>Canna indica</i> L. (Cannaceae)	Control	1.50 $\pm$ 0.31	8.00 $\pm$ 0.95	24.41 $\pm$ 6.00
	Polluted	1.95 $\pm$ 0.87	9.11 $\pm$ 1.99***	34.67 $\pm$ 11.11
<i>Eulophia quartiniana</i> A. Rich (Orchidaceae)	Control	1.77 $\pm$ 1.25	4.32 $\pm$ 0.81	19.00 $\pm$ 4.11
	Polluted	1.50 $\pm$ 0.16	6.75 $\pm$ 0.73***	27.11 $\pm$ 6.450
<i>Euphorbia trigona</i> Haw. (Euphorbiaceae)	Control	1.20 $\pm$ 1.01	6.00 $\pm$ 0.72	21.34 $\pm$ 7.70
	Polluted	1.50 $\pm$ 0.07	8.18 $\pm$ 3.22**	27.12 $\pm$ 3.760
<i>Nerium oleander</i> L. (Apocynaceae)	Control	1.60 $\pm$ 0.33	7.00 $\pm$ 1.37	22.40 $\pm$ 7.15
	Polluted	2.80 $\pm$ 0.44***	10.33 $\pm$ 3.13**	28.20 $\pm$ 6.950

* = Significant at p<0.1% level, ** = Significant at p<0.05% level, *** = Significant at p<0.01% level

Table 4: Effect of autoexhaust pollution at Khartoum city on the micromorphology of some ornamentals in the lower surface of the leaf (Values are means $\pm$ SD of 10 observations/parameter)

Plant species (Botanical family)	Location	Length of stomata (L) (μm)	Breadth of stomata (B) (μm)	L/B ratio	Calculated area of stomata (μm^2)
<i>Argyrea nervosa</i> Bojer (Convolvulaceae)	Control	27.34 $\pm$ 1.280	4.47 $\pm$ 0.37	6.11 $\pm$ 1.44	122.20 $\pm$ 18.03
	Polluted	18.11 $\pm$ 2.11	3.27 $\pm$ 0.69*	5.53 $\pm$ 1.00	59.21 $\pm$ 13.76
<i>Aristolochia elegans</i> Mast. (Aristolochiaceae)	Control	40.82 $\pm$ 2.500	4.63 $\pm$ 0.60	8.81 $\pm$ 1.20	188.99 $\pm$ 18.00
	Polluted	26.00 $\pm$ 3.00***	3.00 $\pm$ 0.41***	8.66 $\pm$ 2.22	78.00 $\pm$ 15.30
<i>Barleria calophylla</i> Lindau (Acanthaceae)	Control	12.13 $\pm$ 1.580	5.44 $\pm$ 0.46	2.22 $\pm$ 1.15	65.98 $\pm$ 14.02
	Polluted	9.30 $\pm$ 0.34***	3.90 $\pm$ 0.66***	2.38 $\pm$ 1.65	36.27 $\pm$ 3.500
<i>Bauhinia candida</i> Act. (Caesalpiniaceae)	Control	21.57 $\pm$ 2.750	6.28 $\pm$ 0.75	3.43 $\pm$ 0.76	135.45 $\pm$ 16.24
	Polluted	19.28 $\pm$ 2.60	6.80 $\pm$ 1.00	2.83 $\pm$ 0.65	131.10 $\pm$ 17.04
<i>Begonia elatior</i> Hort. (Begoniaceae)	Control	15.18 $\pm$ 3.450	5.38 $\pm$ 0.71	2.82 $\pm$ 1.60	81.66 $\pm$ 19.30
	Polluted	14.00 $\pm$ 3.41	3.47 $\pm$ 0.48**	4.03 $\pm$ 2.11	48.58 $\pm$ 16.48
<i>Caladium hortulanum</i> Birdsey (Araceae)	Control	19.36 $\pm$ 3.460	4.11 $\pm$ 1.32	4.71 $\pm$ 1.85	79.56 $\pm$ 12.01
	Polluted	14.90 $\pm$ 3.99**	5.22 $\pm$ 1.88	2.85 $\pm$ 1.56	77.77 $\pm$ 16.28
<i>Canna indica</i> L. (Cannaceae)	Control	24.88 $\pm$ 2.810	5.20 $\pm$ 1.33	4.78 $\pm$ 1.25	129.37 $\pm$ 18.00
	Polluted	18.41 $\pm$ 0.75***	4.17 $\pm$ 0.75***	4.41 $\pm$ 1.38	76.76 $\pm$ 13.00
<i>Eulophia quartiniana</i> A. Rich (Orchidaceae)	Control	13.23 $\pm$ 0.650	5.12 $\pm$ 0.72	2.58 $\pm$ 0.88	67.73 $\pm$ 10.50
	Polluted	5.88 $\pm$ 1.98***	2.30 $\pm$ 1.46***	2.55 $\pm$ 1.89	13.52 $\pm$ 1.780
<i>Euphorbia trigona</i> Haw. (Euphorbiaceae)	Control	13.00 $\pm$ 1.600	6.28 $\pm$ 1.50	2.07 $\pm$ 0.90	81.64 $\pm$ 19.90
	Polluted	8.00 $\pm$ 2.17	3.22 $\pm$ 0.40***	2.48 $\pm$ 0.75	25.76 $\pm$ 4.640
<i>Nerium oleander</i> L. (Apocynaceae)	Control	29.33 $\pm$ 2.500	5.17 $\pm$ 0.75	5.67 $\pm$ 0.98	151.16 $\pm$ 16.00
	Polluted	25.18 $\pm$ 2.54	3.38 $\pm$ 0.46***	7.44 $\pm$ 1.95	85.10 $\pm$ 17.40

* = Significant at p<0.1% level, ** = Significant at p<0.05% level, *** = Significant at p<0.01% level

Length, breadth and calculated area of stomata exhibited different percentages of inhibition whereas number of stomata, epidermal cells and stomatal index showed stimulation. It is obvious that *Aristolochia elegans* Mast. (Aristolochiaceae) showed more number of parameters inhibited in maximum percentage and was considered a good indicator of auto-exhaust pollution and the most sensitive one while *Nerium oleander* L. (Apocynaceae) was the most resistant plant. Similar observations were made by Salgare and Lyer (1991),

Salgare and Rawal (1990) and Darrall (1989). Since ornamental plants were found polluted severely area, it would therefore suggest that emphasis must be given for the control of auto-exhaust pollution in the area.

CONCLUSION

Several differences were recorded and showed significant inhibition due to the auto-exhaust pollution. In polluted sites, leaves became smaller with reduced length

and width and stomatal index per leaves area. These changes corresponded to rate of auto-exhaust density regardless of mean annual air temperature of each site. The results indicate that micro morphology in ornamental leaves is an emergent property, the magnitude of which is environmentally constrained.

REFERENCES

- Bondada, B.R., and C. Tu and L.Q. Ma, 2006. Surface micro-morphology of chinese brake fern (*Pteris vittata* L.). *Brittonia*, 58: 217-228.
- Cooper, A., I.A.E. Atkinson, W.G. Lee and T.H. Worthy, 1993. Evaluation of the Moa and their effect on the New Zealand flora. *Trends Ecol. Eval.*, 8: 433-437.
- Darrall, N.M., 1989. The effect of air pollutants on physiological processes in plants. *Plant Cell Environ.*, 12: 1-30.
- Dickison, W.C., 2000. *Integrative Plant Anatomy*. Harcourt Academic Press, Massachusetts.
- Fahn, A., 1967. *Plant Anatomy*. Pergamon Press, Exeter, UK., pp: 193-219.
- Feder, W.A., 1970. Plant response to chronic exposure to low levels of oxidant type air pollution. *Environ. Pollut.*, 1: 73-90.
- Garg, K.K. and C.K. Varshney, 1980. Effect of air pollution on the leaf epidermis at the submicroscopic level. *Experientia*, 36: 1364-1366.
- Guderian, R., 1977. *Air pollution*. Springer-Verlag, Berlin, Germany.
- Halloy, S.R.P. and A.F. Mark, 1996. Comparative leaf morphology spectra of plant communities in New Zealand, the Andes and the European AIPS. *J. Royal Soc. New Zealand*, 26: 41-78.
- Heck, W.W., O.C. Taylor and H.E. Heggstad, 1973. Air pollution research needs: Herbaceous and ornamental plants and agriculturally generated pollutants. *J. Air Pollut. Control Assoc.*, 23: 257-266.
- Heggstad, H.E., 1968. Diseases of crops and ornamental plants incited by air pollutants. *Phytopathology*, 58: 1089-1089.
- Meinder, H. and T.A. Mansfield, 1968. *Physiology of Stomata*. McGraw Hill, New York.
- Mukammal, E.I., 1976. Review of present knowledge of plant injury by air pollution. Geneva: Secretariat World Meteorol. Org., Vol. 14.
- Orshan, G., 1986. Plant forms as describing vegetation and expressing adaptation to environment. *Annales Botanici*, 44: 7-38.
- Salgare, S.A. and M. Rawal, 1990. Effect of auto-exhaust pollution at Andheri (West), Bombay on anatomy of some cultivated plants (monsoon season). *J. Ecobiol.*, 2: 273-280.
- Salgare, S.A. and M.P. Lyer, 1991. Effect of auto-exhaust pollution at Byculla on the micro-morphology of some weeds. *New Griculturist*, 1: 123-128.
- Salisbury, E.J., 1927. On the causes and ecological significance of stomatal frequency with special references to woodland flora. *Philosophical Transactions of the Royal Society of London. Series B, Containing Papers of a Biological Character*, Volume 216.
- Sharma, G.K. and J. Butter, 1975. Environmental pollution, leaf cuticular patterns in *Trifolium pretense* L. *Ann. Botany*, 39: 1087-1090.
- Sharma, G.K. and J. Tyree, 1973. Geographic leaf cuticular and gross morphological variations in *Liquidamber styraciflus* and their probable relation to environmental pollution. *Boi. Gaz.*, 134: 179-184.
- Singh, N., M. Yunus, K. Srivastava, S.N. Singh, V. Pandey, T. Misra and K.J. Ahmad, 1995. Monitoring of auto-exhaust pollution by roadside plants. *J. Environ. Monitor. Assess.*, 34: 13-25.
- Solberg, R.A. and D.P. Adams, 1956. Histological responses of some plant leaves to hydrogen fluoride and sulfur dioxide. *Am. J. Botany*, 43: 755-760.
- Weyers, J.D.B. and A.J. Travis, 1981. Selection and preparation of leaf epidermis for experiments on stomatal physiology. *J. Exp. Bot.*, 32: 837-850.