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FOLIAR ECO-PHYSIOLOGICAL RESPONSE OF SOME TROPICAL TREE SPECIES TO COAL SMOKE POLLUTION

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A study carried out to assess the impact of coal smoke pollution on certain physiological parameters and elemental contents of the foliage of three tropical tree species viz., *Eucalyptus citriodora, Dalbergia sissoo* and *Tectona grandis* has revealed that photosynthetic pigments (chlorophylls and carotenoids),NPK level, carbohydrate and protein contents decreased in all the investigated species. However, sulphate- sulphur content recorded significant elevation in the foliage of tree species at the test site, the maximum increase being exhibited by *D. sissoo* followed by *E. citriodora* and least in *T. grandis*.

Keywords : Carbohydrate; Chlorophylls; Coal smoke; NPK; Protein; Tree species.

Introducton

Sulphur dioxide is the major phytotoxic pollutant in coal smoke causing damage to vegetation in terms of foliar injury[1], physiological and biochemical perturbations[2,3] and also growth reductions[4]. The extent of injury depends on concentration, fumigation frequency, duration of exposure and operating environmental factors[5]. It has also been found that at higher concentrations plants are reported to exhibit injury symptoms (visible injury) and at lower concentrations plants experience certain physiological and metabolic disturbances[6]. An adequate attention has been given to evaluate the responses of different species under artificial fumigation conditions and not much attention has been paid to the plants growing under ambient field conditions, where the plant community experiences the interactive effect of different pollutants. The present work is therefore, an attempt in this direction with the objective to assess the relative sensitivity of three economically important tree species of tropical India, viz., *Eucalyptus citriodora* Hook. (Myrtaceae); *Dalbergia sissoo* Roxb. (Papilionaceae), and *Tectona grandis* Linn.(Verbenaceae) to coal smoke pollution emanating from a thermal power plant.

Materials and Methods

The present investigation was undertaken at Department of Botany, A.M.U., Aligarh, U.P., India during the year 1997-98. Ten individuals of each tree species viz., *Eucalyptus citriodora*, *Dalbergia sissoo* and *Tectona grandis* having almost similar age (10 years) were selected at a distance of 1.5 km from thermal power plant, Kasimpur (Aligarh) in a windward direction (Polluted site) and 16 km from thermal power plant in a cross wind direction (Control site). The area has a typical monsoon type of climate characterized by seasonal rhythm. The average maximum and minimum temperature, relative humidity and rainfall during the investigation were 35.50 & 19.96 °C, 91 & 37% and 338 and 18 mm, respectively. The amount of SO_2, NO_x and CO_2 released with coal smoke from the thermal power plant during the same period was 0.0145, 0.255 and 2.312 ppm hr^{-1}, respectively.

Mature leaves from all the sides of tree canopy were collected during the months of July to October. Hundred samples from ten replicating individuals of each tree species from both sites were taken. The leaf samples were analyzed for total chlorophyll, chlorophyll-a and b, and carotenoid by non-maceration method using dimethyl sulphoxide (DMSO)[7]. The determination of total nitrogen, phosphorus and potassium content were also accomplished by micro-kjaldhal method[8]. Sulphate-sulphure, total carbohydrate and protein contents of leaf samples were estimated following the method of Patterson[9], Dubois *et al.*[10] and Lowry *et al.*[11], respectively. The soil analysis of both control and polluted sites were carried out at the Agricultural Directorate (Soil Survey and Research) Aligarh. The data were finally subjected to CRD analysis[12] and compared by '**t**' test.

Results and Discussion

The data (Table 1) indicates that the chlorophyll a and b as well as total chlorophyll experienced marked reductions in the pollution affected population. The reduction in chlorophyll-a being higher in *T. grandis* (39%) ($P < 0.01$ level) followed by *E. citriodora* (35%) and minimum in *D. sissoo* (26%). Similar coal smoke induced chlorophyll destruction has been earlier reported by many workers[2,4,13]. The degradation of chlorophyll pigment might be due to

Table 1. Impact of coal smoke pollution on some physiological characteristics of tree species

Parameters	Site	*Eucalyptus citriodora*	*Dalbergia sissoo*	*Tectona Grandis*
Chlorophyll-a (mg/g fresh wt.)	P	0.854+0.009	1.391+0.037	0.856+0.020
	C	1.311+0.077	1.882+0.058	1.401+0.009
		(-35)*	(-26)**	(-39)**
Chlorophyll-b (mg/g fresh wt.)	P	0.250+0.028	0.407+0.034	0.636+0.010
	C	0.330+0.021	0.521+0.028	0.918+0.039
		(-24)**	(-22)**	(-31)**
Carotenoids (mg/g fresh wt.)	P	0.105+0.020	0.194+0.017	0.475+0.015
	C	0.165+0.029	0.370+0.016	0.647+0.032
		(-36)*	(-48)*	(-27)**
Total chlorophyll (mg/g fresh wt.)	P	1.104+0.45	1.798+0.021	1.492+0.081
	C	1.641+0.071	2.403+0.045	2.319+0.065
		(-32)*	(-25)*	(-35)
Sulphate-sulphur (% dry weight)	P	0.300+0.014	0.580+0.054	0.325+0.021
	C	0.210+0.020	0.340+0.041	0.245+0.34
		(+43)*	(+71)*	(+33)*
Total nitrogen (% dry weight)	P	2.40+0.141	2.70+0.141	1.85+0.114
	C	2.50+0.114	3.25+0.141	2.25+0.200
		(-4)*	(-17)**	(-18)**
Phosphorus (% dry weight)	P	0.200+0.060	0.120+0.022	0.255+0.050
	C	0.355+0.046	0.195+0.58	0.345+0.049
		(-44)*	(-38)*	(-26)*
Potassium (% dry weight)	P	0.625+0.050	0.810+0.076	0.455+0.064
	C	0.090+0.085	1.325+0.122	0.525+0.050
		(-43)*	(-39)*	(-13)**
Total carbohydrate (%dry weight)	P	9.60+0.70	13.80+0.54	11.80+1.16
	C	12.50+0.88	14.80+1.03	12.40+0.45
		(-23)*	(-6)**	(-4)*
Protein (mg/ g fresh weight)	P	7.95+0.74	15.40+0.80	17.35+0.97
	C	8.25+0.39	18.50+0.80	21.35+0.74
		(-4)*	(-17)**	(-19)*

Values are mean + standard deviation P= Polluted site; C= Control site
Parantheses indicate per cent increase or decrease over control
*,** Significant at 0.1 level, and 0.5 level, respectively.

Table 2. Soil characteristic of the polluted and control sites

S. No.	Parameter	Site P	Site C	Per cent variation
1.	pH	7.60	8.00	(-5)**
2.	Total N (%)	0.070	0.076	(-8)*
3.	Available P (%)	0.080	0.085	(-6)*
4.	Exchangeable K (%)	0.075	0.077	(-3)**
5.	Sulphur (mg/g)	500	285	(+75)*

Site P = polluted site Site C = control site
*, ** Significant at 0.1 and 0.5 level respectively.
[Soil analysis carried out at the Agricultural Directorate (Soil Survey and Research) Aligarh.

the action of SO_2 on chlorophyll metabolism[14] or due to SO_2 induced removal of Mg^{++} ions by two atoms of hydrogen from chlorophyll molecule which converts chlorophyll into phaeophytin[15] or by the production of superoxide radicals by the action of sulphite with chlorophyll under illumination[16]. On the other hand some workers are of the openion that H^+, HSO^-_3, SO_3^{-2} and SO_4^{-2} ions, which are produced by SO_2 dissolution in water in the cytoplasm are preferentially incorporated in to thylakoid membranes[17] and induce chloroplast swelling[18].

It is also evident from the data that in all the investigated species, chlorophyll-a recorded severe losses due to pollution stress compared to chlorophyll-b. The higher sensitivity and greater susceptibility of chlorophyll-a to sulphur pollution might be ascribed to the inactivation of various enzymes associated with the synthesis and action of chlorophyll-a[19]. The observations also showed that carotenoid contents although recorded losses in all the tree species, the maximum reduction was found in *D. sissoo* (48%) and minimum in *T. grandis* (27%). These findings are in conformity with the earlier reports[20].

The foliar sulphate contents in all the three species growing in the polluted zone was significantly higher than measured in the reference population. This clearly shows that SO_2 is a major pollutant in the ambient air around the thermal power plant and its greater entry into the leaf system of the species growing at the test site. Similar increase in the sulphur contents in the foliage of plants growing in SO_2 polluted areas has also been reported earlier by several investigators[3,21,22]. From the present study it is also clear that the amount of accumulated sulphur was more in *D. sissoo* (71% at $P > 0.01$ level) and less in *T. grandis* (33% at $p > 0.01$ level).A comparatively lesser amount of sulphur accumulation in *T. grandis* indicated that either this species is highly sensitive to SO_2 and does not allow the further entry of gas into its leaf system or has higher potential to metabolise the inorganic sulphur into organic sulphur.

Air pollutants are well known to influence the mineral accumulation in plants directly or indirectly. In the present study it has been observed that the contents of essential mineral nutrients like N, P and K invariably decreased in the foliage of the polluted population. The depletion of N contents in the pollution stressed population may be due to the loss in protein synthesis[23] or due to the inactivation of enzymes responsible for protein synthesis[24]. Also the decrease in P level in the pollution affected plants indicates the inhibition of certain enzymatic activities involved in P metabolism.Further it is also expected that plants under physiological stress conditions are likely to loose much energy (ATP/ NADP) and therefore may be utilizing P to its maximum possible extent to combat the stress. The loss of K in the plants growing in the polluted atmosphere signifies that coal smoke pollution hampers the K metabolism in plants. Lone[3,25], has also observed reductions in NPK contents of the foliage of some tropical tree species affected by coal smoke pollution.

Since coal smoke pollution has also brought about the changes in the chemical properties of the soil (Table 2) therefore, the variation in the soil macronutrients and pH may be ascribed to the acidity produced by the surplus amount of sulphur in the soil. Such changes in the soil nutrients may lead to anion-cation disbalance in the long run. Agrawal *et al.*[26] have reported that NPK level get decreased in the soil affected by SO_2 pollution. Thus depletion of NPK level in the soil at the polluted site as observed in the present study might also be one of the reasons of their low concentrations in the foliage of affected population.

The percentage of carbohydrate in the population growing at the test site was reduced more in *E. citriodora* (23%) than other two species. Such reductions are in agreement with the observations of Koziol and Jordan[27] and Lone[3]. On the other hand foliar protein contents of *T. grandis* recorded severe loses (19%) which may be attributed to changes in amino acid concentration which ultimately leads to protein reduction[28]. So on the basis of the present study it may be concluded that coal smoke pollution affects various physiological and biochemical parameters of plants and relative response of different species depend on the inherent character of the species concerned.

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