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Environmental Contamination and Toxicology

Transfer Experiment Study on Two Winter Annuals around a Coal-Fired Power Plant

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Coal accounts for more than 70% (87.3 million tonnes) of the total power generation in India and its consumption is expected to reach 212.8 million tonnes yearly by the year 2000 (Anonymous, 1988). Burning of such a huge quantity of coal would result in the release of a vast amount of gaseous and particulate pollutants. Of these pollutants, SO_2 and fly-ash rank much higher in the order of inflicting injury to plants. The multiple effects of SO_2 on plant metabolism include chlorophyll reduction (Schulz, 1986), decrease in protein (Malhotra & Khan, 1984; Singh et. al., 1990) and ascorbic acid level (Varshney & Varshney, 1984) and increase in free amino acid content (Khan et. al., 1990). Garg & Varshney (1985) reported increased leaf surface temperature of fly-ash exposed plants. These parameters are sensitive to air pollutants and can serve as indicators of air pollution stress.

In the field, various factors, e.g., soil, water and agricultural practices, other than air pollution influence plant growth. To reduce these variables to a minimum transfer-experiment i.e. placing potted plants at selected locations/environs were carried out on two popular winter annuals viz. *Aster amellus* and *Tropaeolum majus*. The choice of these plants for the present experiment is based on the earlier observations (during field surveys of the area) that indicated the potentiality of these plants to be used as pollution markers.

MATERIALS AND METHODS

The Riverside Power House (RPH), generation capacity of 65 MW, at Kanpur city was selected for the present study. The power plant is not provided with electrostatic precipitators and thus spews large amounts of particulate pollutants along with SO_2. Five sites falling in windward (leeward) directions on a transect were selected for placing the pots. Air quality for SO_2 and fly-ash of all the selected sites was monitored and details of sites are summarized (Table 1).

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Table 1. Description of Sites and Background SO_2 and SPM Levels.

Symbol	Distance	Direction	SO_2* (ppm) min.	max.	SPM* (ug/m^3) min.	max.
R_1	50	SW				
R_2	100	E	0.06	0.11	146.28	383.08
R_3	150	W	0.03	0.06	161.90	218.81
R_4	500	SW(WW)	0.05	0.15	145.20	266.90
R_5	1000	SE(WW)	0.05	0.14	141.90	247.98
C	8000	SW	0.01	0.02	52.79	142.28

* 8 hourly average.

Seeds of Aster amellus L. and Tropaeolum majus L. were sown in nursery beds at experimental plots of the Institute (NBRI). The seedlings were then transplanted in 10" earthen pots. After establization of the seedlings, sets of ten plants each were placed at sites R_1, R_2, R_3, R_4, R_5 and C. The plants were sampled at pre-flowering (I), flowering (II) and post-flowering stages (III). The photosynthetic pigments, amino acids, protein and ascorbic acid in leaves were estimated following the methods of Maclachlan & Zalik (1963), Plummer (1971), Lowry et. al. (1951) and Keller & Schwager (1977), respectively. Sulphur dioxide concentration in the ambient air at all the sites was measured with pulsed fluorescent SO_2 gas analyser (TECO model 43) and suspended particulate matter (SPM) with Anderson's high volume sampler. Monitoring could not be done at R_1, because the entry of the instruments was not permitted inside the power house for administrative reasons.

RESULTS AND DISCUSSION

None of the plants at any site manifested any perceivable foliar injury (- naked injury), however, they suffered significantly for certain hidden parameters (+ hidden injury).

Plants kept at sites, loaded with relatively higher concentrations of pollutants exhibited more pronounced effects falling in the prevailing wind direction, further, an inverse correlation between the distance and effect on plants was also validated.

Plants of both the species at R_4 site with the highest level of SO_2 exhibited maximum reduction of chlorophyll contents ($P < 0.01$). The loss of content was, however, highest at post-flowering stage (58 & 55% in *A. amellus*, Fig.1; and *T. majus*, Fig.2, respectively, $p < 0.01$). A significant reduction of the chlorophyll pigments in both plant species at all the polluted sites may be safely attributed to poor synthesis for two circumstantial reasons: (1) absence of any obvious injury i.e., no degradation of chlorophyll molecules, (2) presence of thick fly-ash and unburned coal particles coating the leaf surfaces and subjecting an increase in foliar temperature, and eventually retarding the chlorophyll synthesis. Garg & Varshney (1985) have also reported reduced synthesis of chlorophyll molecules due to thermal power pollutants.

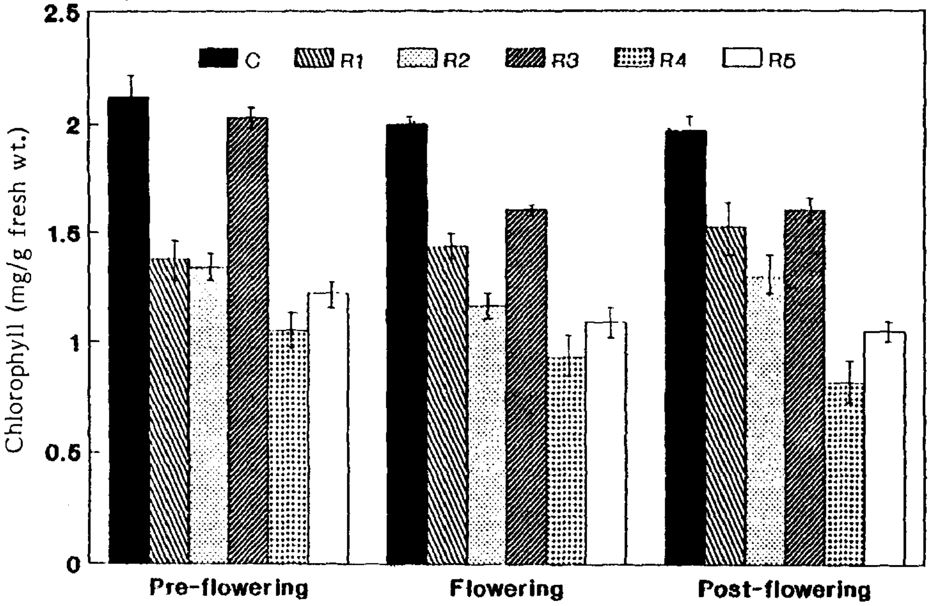
The increase (in %) in free amino acid content in *A. amellus* was maximum at R_4 (42,100,97) followed by R_5 (37,65,75) and R_2 (17,31,19) at pre, flowering, and post-flowering stages, $p < 0.01$ (Fig.3). The same trend was present in *T. majus* (Fig.4), i.e., maximum at R_4 (77,119,118) followed by R_5 (61,115,90) and R_2 (58,80,54), ($p < 0.01$). The increase in amino acid content as a sequel to SO_2 exposure has been reported by Karokewski (1985). This increase is generally associated with protein depletion (Ito *et. al.*, 1986). Reports correlating free amino acid accumulation with protein hydrolysis, based on the data from the field environment, suggest that an additional source of nitrogen may also result in the increase of amino acid content in the plants facing air pollution (Zedler *et. al.*, 1986). Since the investigated plant species were kept around a coal fired power house, the emission of which contains considerable amount of NO_x, plants would have received more nitrogen resulting in increased amino acid synthesis.

A marked reduction in protein content in both the plant species was observed. In *A. amellus* maximum decrease occurred at the flowering stage in all the sites, R_1-22, R_2-15, R_3-18, R_4-33, R_5-27%; $p < 0.01$ (Fig.5). In *T. majus*, however,, most of the decrease occurred at post-flowering stage, R_1-23, R_2-33, R_3-12, R_4-52, R_5 -47%; $p < 0.01$ (Fig.6). The decrease in protein content could be attributed to either breakdown of existing proteins (Sardi, 1981) or their reduced *de novo* synthesis (Malhotra & Khan, 1984; Singh *et. al.*, 1990).

Although a decrease in ascorbic acid content was observed in both the plant species, it was significant only at a few sites. In *A. amellus*, at R_4 site, maximum decrease (30,45 and 34%, $p < 0.01$) was found at all the three sampling stages (Fig.7). However, in *T. majus* insignificant decrease occurred (Fig.8). The reduction in the level of ascorbic acid in pollutant-exposed plants has been attributed to enzyme toxicity and sulphonation of -SH groups (Mapson, 1958). Varshney & Varshney (1984) related pollution tolerance of plants with their ascorbic acid levels and concluded that the higher the level of ascorbic acid the greater the tolerance.

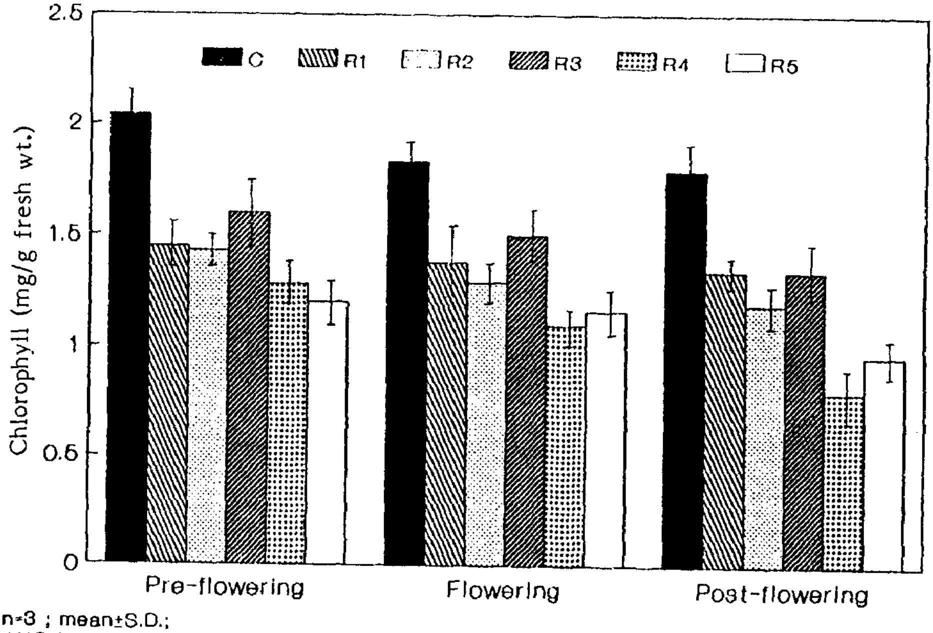
The present study affirms the dose-response relationship depending on the evidence of more conspicuous changes in both

Fig. 1



n=3 ; mean±S.D.;
ANOVA : Site = p<0.01 ; Sample = N.S.

Fig. 2



n=3 ; mean±S.D.;
ANOVA : Site = p<0.01 ; Sample = p<0.01

Figs. 1 and 2, showing the amount of chlorophyll (mg/g fresh wt.) at pre-flowering, flowering and post-flowering stages in the leaves of _A. amellus_ (Fig.1) and _T. majus_ (Fig.2).

Fig. 3

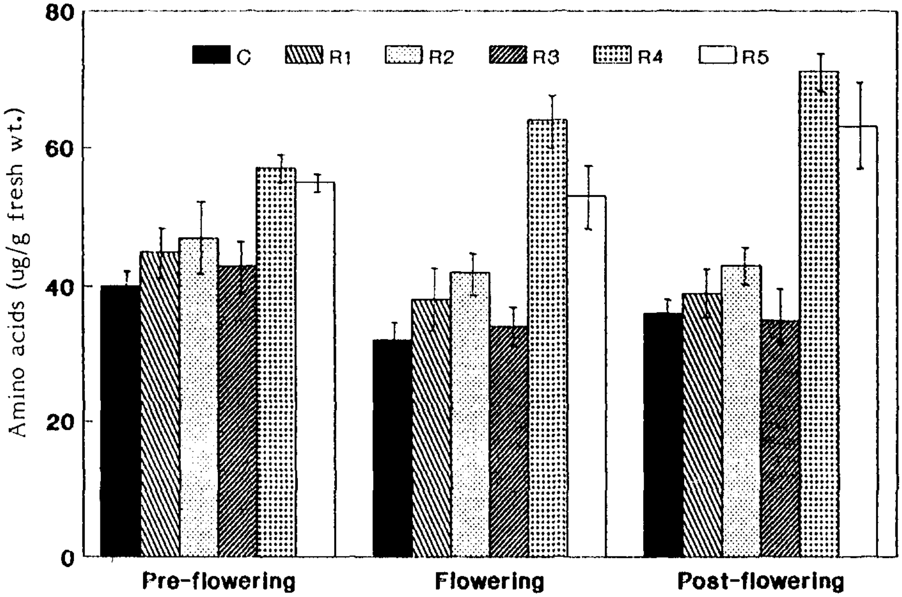


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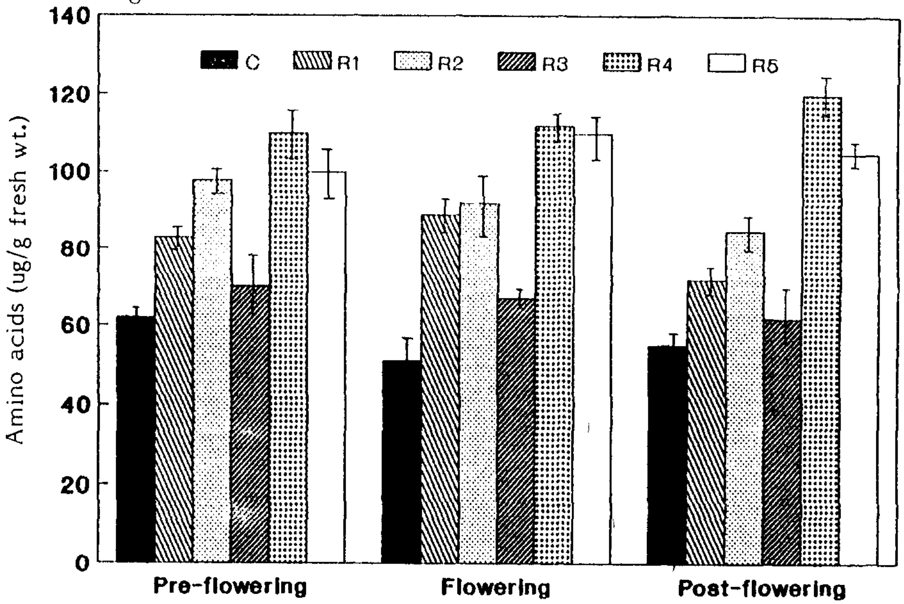
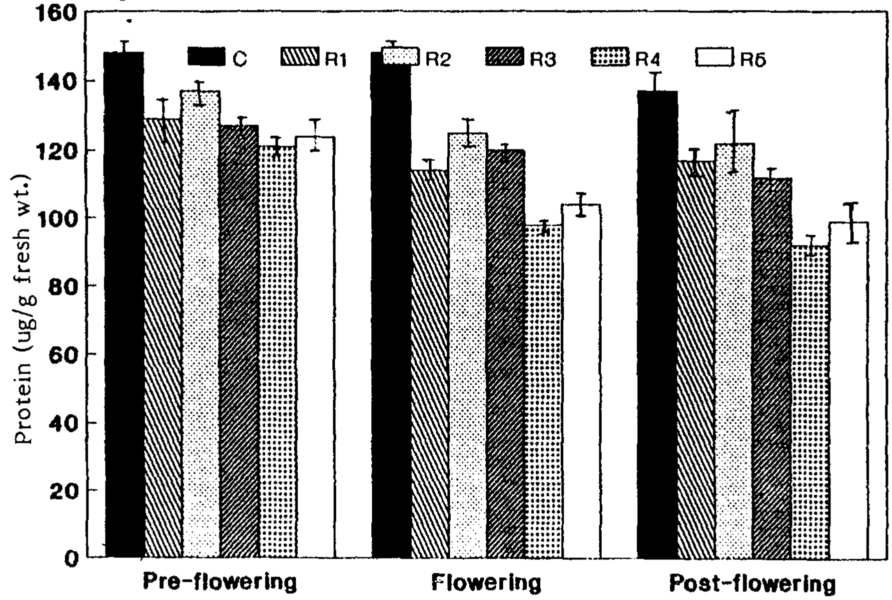
Fig. 4



n=3 ; mean±S.D.;
ANOVA : Site = p<0.01 ; Sample = N.S.

Figs. 3 and 4, showing the amount of amino acid (ug/g fresh wt.) at pre-flowering, flowering and post-flowering stages in the leaves of *A. amellus* (Fig.3) and *T. majus* (Fig.4).

Fig. 5



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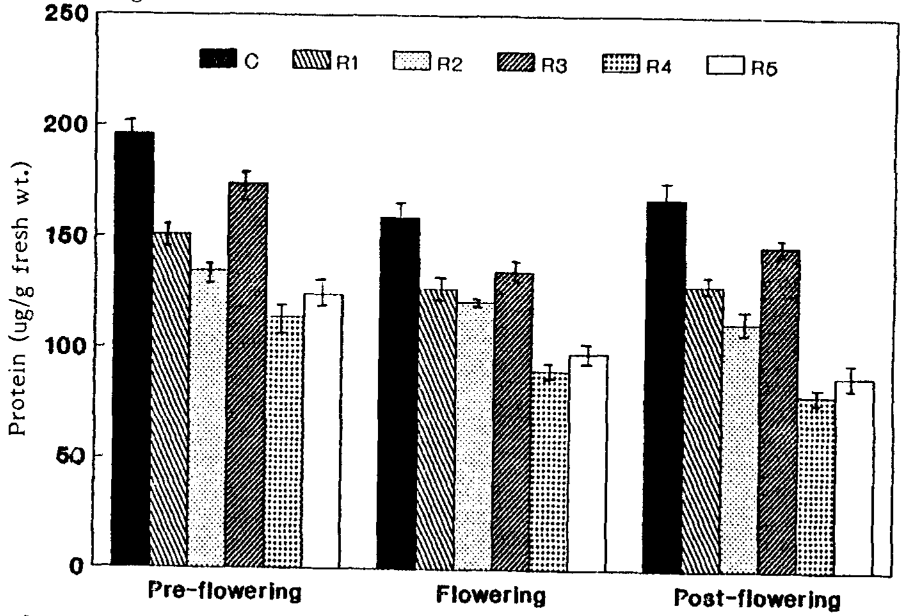
ANOVA : Site = $p<0.01$; Sample = $p<0.01$

Fig. 6



n=3 ; mean±S.D.;
ANOVA : Site = $p<0.01$; Sample = $p<0.01$

Figs. 5 and 6, showing the amount of protein (ug/g fresh wt.) at pre-flowering, flowering and post-flowering stages in the leaves of *A. amellus* (Fig. 5) and *T. majus* (Fig.6).

Fig. 7

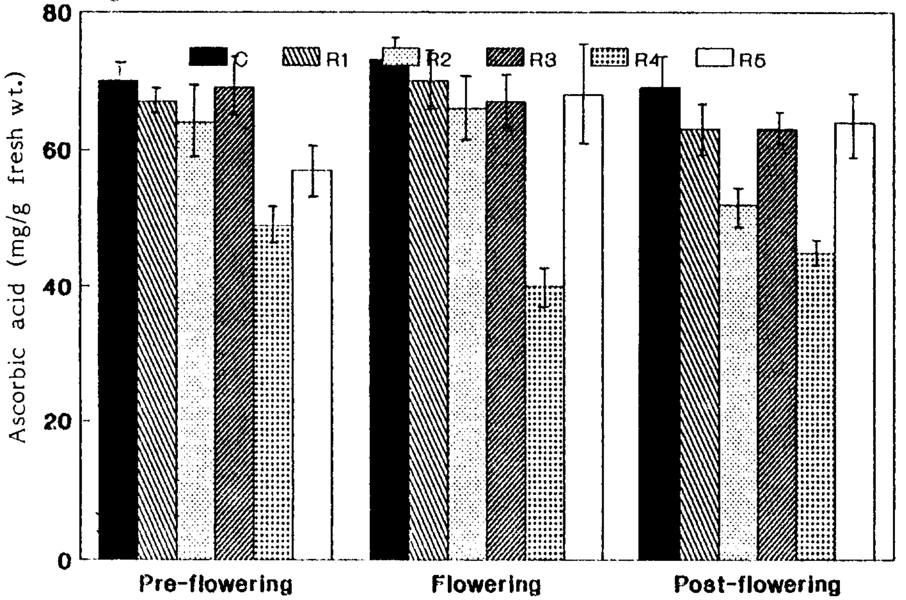


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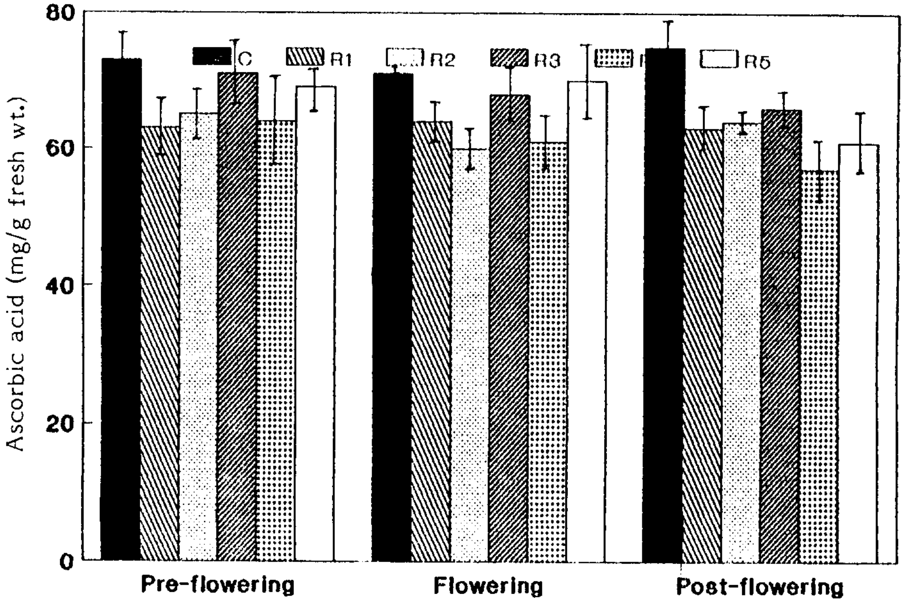
Fig. 8



n=3 ; mean±S.D.;
ANOVA : Site = N.S.; Sample = N.S.

Figs. 7 and 8, showing the amount of ascorbic acid (mg/g fresh wt.) at pre-flowering, flowering and post-flowering stages in the leaves of A. amellus (Fig.7) and T. majus (Fig.8).

species at sites loaded with higher concentrations of SO_2 and fly-ash and further, on an inverse relation with the distance. Albeit A. amellus and T. majus did not manifest any injury symptoms, the parameters studied were so sensitive that both plants can be well recommended as bio-indicators of thermal power emissions.

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