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The effect of air pollutants emerging out of coal-burning at the Thermal Power Plant Complex, Kasimpur, Aligarh, has been studied on the biochemical responses of some perennial broad-leaved forms of tropical origin namely, *Azadirachta indica* (Meliaceae), *Cassia fistula* (Caesalpiniaceae), *Tamarindus indica* (Caesalpiniaceae), *Ficus religiosa* (Moraceae) and *Ficus bengalensis* (Moraceae). The data were collected on the level of sulphur, photosynthetic pigments, carbohydrate, protein, nitrogen, phosphorus, potassium, sodium, calcium, ascorbic acid and proline in the foliage, newly formed bark and sap wood samples.

**Sulphur**

The sulphate-sulphur content shows highly significant accumulation of sulphur in foliage under pollution stress. The peak amount of sulphur occurs in the monsoon foliage in all the species with the exception of *Cassia fistula*. The magnitude of sulphate-sulphur accumulation depends on the season as well as the inherent behaviour of the species concerned. The accumulation of sulphate-sulphur in decreasing order in the foliage falls as, *Ficus religiosa* < *Ficus bengalensis* < *Cassia fistula*, *Azadirachta indica* < *Tamarindus indica*. Similarly in bark, significant amount of sulphur accumulates except in *T. indica*. The highest percentage of sulphur accumulation in bark takes place in *F. bengalensis* and the least in *A. indica*. In wood, also significant amount of accumulation of sulphate-sulphur takes place under coal-smoke pollution.

**Chlorophyll and Carotenoids**

The photosynthetic pigments show severe losses in their amount in all the investigated species, except in *F. bengalensis* in which they increase. Chlorophyll ‘a’
suffers greater loss in *C. fistula* and *T. indica*, while in the rest chlorophyll ‘b’ undergoes greater loss under coal-smoke pollution. The peak amount of photosynthetic pigments has been found in the monsoon foliage in all the species irrespective of pollution level. The ratio of chlorophyll ‘a’ to chlorophyll ‘b’ ranges from 1:0.61 to 1:0.77 under pollution. The carotenoid contents also shows decreasing trend under pollution. The ratio of carotenoids to chlorophyll varies from 1:0.22 to 1:0.26 in the control and from 1:0.18 to 1:0.26 in polluted populations. The correlation of photosynthetic pigments with sulphur shows negative relationship in all the species except in *F. bengalensis*, where the correlation turns out to be positive.

**Carbohydrate**

Under coal-smoke pollution, all the species have recorded increase in carbohydrate in the foliage, except in *T. indica*. In *A. indica*, *C. fistula* and *F. bengalensis* there has been a steady increase of carbohydrate from younger to older foliage. The increase in carbohydrate under pollution stress has been the maximum in the foliage of *F. bengalensis*, followed by *A. indica*, *C. fistula* and *F. religiosa*. The amount of loss or gain under coal-smoke pollution has been more pronounced in wood than in bark and the foliage. In bark, all the species have recorded gradual increase in carbohydrate from summer to winter except in *C. fistula*. The bark samples of *A. indica*, *C. fistula* and *F. religiosa* record increased amount of carbohydrate under pollution. The concentration of carbohydrate is higher in wood than in the foliage and bark in the normal as well as polluted atmosphere. All the species have recorded decreased level of carbohydrate in wood under coal-smoke pollution except in *F. bengalensis*. The correlation of carbohydrate with sulphur shows, negative as well as positive relationship in different species in various season, in the foliage, bark and wood. Similarly, the correlation with photosynthetic pigments shows varied pattern in different species.
Protein

The protein content shows increasing trend under coal-smoke pollution in all the investigated species except in *T. indica*. However, the significant interaction has been found only in *F. bengalensis*. The concentration of protein showed varied trend in different species in various season. In bark, the decreased level of protein has been recorded under pollution stress in *C. fistula* and *Ficus* spp.. The seasonal variation in bark has been found to be non-significant in *A. indica*, *C. fistula* and *Ficus* spp.. In wood, *A. indica*, *T. indica* and *F. religiosa* record increase in the amount of protein, while the rest show decreased level of protein under coal-smoke pollution. The highest increase in protein level in wood under pollution occurs in the winter samples of *A. indica* while the loss attains the maximum in the summer samples of *F. bengalensis*. The correlation of protein with sulphur in the foliage shows mostly positive relationship, with varying level of significance. In bark and wood it shows negative as well as positive relationship in different species.

Nitrogen

The nitrogen content in the foliage follow the same trend as described in case of protein under coal-smoke pollution. The investigated species have recorded increased accumulation of nitrogen in the foliage under pollution except in *T. indica*. In *A. indica* and *F. religiosa* there has been a decrease in nitrogen content from younger to older foliage. The accumulation of nitrogen under pollution stress in decreasing order falls as, *A. indica*, *F. bengalensis*, *F. religiosa* and *C. fistula*. In bark, significant accumulation of nitrogen under coal-smoke pollution has been recorded in *A. indica* and *T. indica*, while in the rest nitrogen level decreased compared to control. In wood, *A. indica*, *T. indica* and *F. religiosa* indicate increased nitrogen content under coal-smoke pollution, while the rest of the species show decreased amount under similar condition. The seasonal trend in nitrogen accumula-
tion also varies in different species in wood. The correlation of nitrogen content with sulphur in the foliage shows positive relationship in all the species with the exception of T. indica in which the correlation is negative. In bark and wood, A. indica and T. indica show positive correlation in different season, while in the rest of the species, the pattern of correlation varies.

**Phosphorus**

The phosphorus content show increasing trend under coal-smoke pollution in the foliage of Ficus spp., while in the rest there has been a significant loss. T. indica did not show any change statistically under coal-smoke pollution. In all the species studied the peak level of phosphorus is recorded in summer except in T. indica which has got a monsoon peak. This vital element experiences severe depletion in the bark samples of C. fistula, T. indica, and F. bengalensis, while the rest of the species show gain in their phosphorus content under pollution. The concentration of phosphorus increases from summer to winter in the samples of bark in all species except in A. indica and F. bengalensis. The sap wood samples show higher concentration of phosphorus than in the bark A. indica and F. bengalensis show significant increase in the phosphorus content in wood under coal-smoke pollution, while the rest record significant loss. The correlation of phosphorus with sulphur content in the foliage shows positive as well as negative relationship in different species. The trend has been almost similar in bark and wood.

**Potassium**

The potassium content in the foliage of Ficus spp. experiences significant depletion under coal-smoke pollution, while in T. indica there has been a significant accumulation. The rest of the species show non-significant variation. In the polluted atmosphere T. indica has shown the maximum ability to accumulate potassium in
foliage and the minimum is shown by A. indica. In C. fistula and Ficus spp. the
maximum per cent variation in potassium under coal-smoke pollution has been
observed in winter. In bark the concentration of potassium shows higher than in wood.
A. indica and Ficus spp. show significant depletion in the level of potassium in bark
under coal-smoke pollution, while T. indica has shown increase as in the case of
leaves. A. indica and F. bengalensis record the peak amount of potassium in the
monsoon samples irrespective of treatments. C. fistula shows a unique behaviour by
recording positive variation in potassium in summer and winter, and a significant
negative variation in monsoon. In wood the investigated species show increased as
well as decreased level of potassium content under coal-smoke pollution. The
maximum depletion in potassium content in wood under coal-smoke has been shown
by the monsoon samples of F. religiosa, and the maximum gain is recorded in the
summer samples of T. indica. The correlation of potassium with sulphur shows
positive as well as negative relationship in the leaves, bark and wood samples of
different species.

Sodium

The foliage of A. indica, C. fistula and T. indica records significant increase
in sodium content under coal-smoke pollution, while in the rest of the species there
has been a significant loss. The peak amount of sodium accumulation has been
recorded in the monsoon foliage of all the species, but the interseasonal variation
happens to be non-significant in A. indica and F. religiosa. The maximum accumula-
tion of sodium occurs in the winter foliage of C. fistula over the control, and the
maximum loss is experienced in the monsoon foliage of F. bengalensis. The sodium
content in bark shows different pattern under pollution. In A. indica and F. religiosa
the peak concentration of sodium is recorded in winter, while in the rest the same
happens in other seasons. The maximum gain in sodium in bark under coal-smoke
pollution occurs in the monsoon samples of *C. fistula* and the maximum loss occurs in the winter samples of *F. bengalensis*. All the species show decreased level of sodium in wood under pollution except *T. indica*. The maximum loss occurs in the winter samples of *C. fistula*. The correlation of sodium with sulphur shows negative and positive relationship in different species. The correlation of sodium with potassium depicts non-significant correlation in the foliage, but bark and wood show varied trend.

**Calcium**

The calcium level in the foliage shows reduction under coal-smoke pollution in *C. fistula* and *Ficus spp.*, while in the rest of the species it increases. In *Ficus spp.* the peak level of calcium in the foliage occurs in monsoon, while in the rest the same is record in other seasons. In *A. indica* and *T. indica* it records a non-significant fall in calcium concentration from summer to winter. The per cent variation noted in *C. fistula* and *F. bengalensis* shows significance under pollution stress, while it has been non-significant in the other species. The bark shows the maximum ability to accumulate calcium compared to the foliage and wood in normal as well as polluted atmosphere. The level of calcium increases in the bark samples of all the species under coal-smoke pollution, except in *F. religiosa*. The level of calcium shows gradual increase from summer to winter in all the species. In wood, *C. fistula* and *F. bengalensis* show increasing amount under pollution, while the rest show declining trend. The significant variation of calcium in wood under pollution occurs only in *T. indica*. The correlation of calcium with sulphur shows positive relationship in *A. indica* and *T. indica* in the foliage, while the rest show negative relationship. In bark, all the species show positive relationship with sulphur except in *F. religiosa*, while wood shows a different trend.
Ascorbic acid

The ascorbic acid content shows a decreasing trend under pollution in all the species. The concentration of ascorbic acid in the foliage increases with the age of the leaves. The level of ascorbic acid remains statistically same in *C. fistula* under coal-smoke pollution. In *A. indica*, *T. indica* and *Ficus* spp. as higher loss of ascorbic acid occurs in summer foliage, the degree of loss in ascorbic acid under coal-smoke pollution in decreasing order falls as, *F. religiosa* < *F. bengalensis* < *T. indica* < *A. indica* < *C. fistula*. The correlation of ascorbic acid with sulphur shows significant negative correlation in all the species in different seasons.

Proline

The content increases under coal-smoke pollution in all the species except in *A. indica*. The peak level of free proline records in the winter foliage of all the species after a sharp fall in monsoon, irrespective of treatments. The per cent variation shows maximum and minimum in different seasons. The accumulation of free proline in increasing order under pollution falls as, *F. bengalensis* > *F. religiosa* > *T. indica* > *C. fistula*.

The correlation of proline with sulphur shows positive relationship in all the species except in *A. indica* in which it is negative. The correlation of proline and protein shows negative as well as positive correlation in different seasons. Only the summer samples of *A. indica* shows significant correlation with protein.

The overall assessment of the parameters undertaken in the present study has revealed that all the investigated species are good enough for plantation as they show high tolerance and reasonably good performance under coal-smoke pollution. It is hoped that planting this broad leaved species particularly *Ficus* spp. and *Cassia fistula* in large number at the pollution source may help to maintain the hygienic atmosphere. *Azadirachta indica* a versatile tree of Indian origin is another perennial form which could survive, clean and maintain greeneney in the pollution enriched atmosphere.