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MORPHOLOGICAL AND PHYSIOLOGICAL RESPONSES OF *CROTON BONPLANDIANUM* BAILL. TO AIR POLLUTION

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ABSTRACT

The air pollution stress around the thermal power plant lead to the significant reduction in size and biomass of root and shoot, photosynthetic rate, stomatal conductance, intercellular CO_2 concentration, photosynthetic pigments and photosynthetic area of *Croton bonplandianum*. The resulting stresses of air pollution and reduced foliage further affected the over all morphology and physiology of the plant. Root biomass and chlorophyll a showed maximum reduction than any other selected parameters studied in the stressed area. Chlorophyll a was found to be four and half times more sensitive to air pollutants than carotenoids.

Key words: Air pollution, thermal power plant, morphology and physiology, *C. bonplandianum*.

INTRODUCTION

Air pollution, mainly due to the gaseous emission of industries, thermal power station, automobiles and the domestic combustion, is causing a number of diseases and deformities in living beings, particularly in metropolitan cities. The current widespread use of coal in thermal power plant has contributed sizeably to degradation of the atmosphere. About 80 percent of electricity in India is generated by thermal power plants. The thermal power plants running on sulphur-rich low grade bituminous coal emit enormous amounts of the oxides of sulphur, nitrogen and carbon, various other gases in small quantities, and particulates. These pollutants caused injury and damage to plants and plant parts in a number of ways (Ghouse and Saquib 1986, Yunus and Iqbal 1996, Iqbal *et al*. 2000, Saquib 2008, 2009, Iqbal *et al*. 2010). The extent of injury depends on concentration of gases, fumigation frequency, duration of exposure and the prevailing environmental condition (Thomas and Hendricks 1956). The effects of pollutants may be synergistic, additive or antagonistic depending upon environmental factors and the species involved (Tingey and Reinert 1975). These pollutants caused serious set backs to morphology and physiology of plants. Present study examines the morphological and physiological responses of *Croton bonplandianum* to pollutants emitted due to the coal burning in the thermal power plant.

MATERIALS AND METHODS

Croton bonplandianum Baill (Euphorbiaceae) is a weed plant. Recently antitumor properties from the twig extract of this plant have been observed (Islam *et al*. 2010).

The Badarpur thermal power plant (BTPP) located in South Delhi at the Delhi- Haryana border, at 77°22' E longitude and 28°25' N latitude, and 220 m above sea level, consumes about 10,439 metric tonnes of sulphur rich bituminous coal per day and generates 720 megawatt electricity. The emissions from coal consumption mainly include oxides of sulphur, nitrogen and carbon and particulate matters and other gaseous pollutants in minor quantities (Fig. 1).

Ten matured plants of *Croton bonplandianum* were collected randomly each from the polluted site (near Badarpur Thermal Power Plant Station) and the reference site (Hamdard University campus) located on Badarpur-Mehrauli road at 10 km west from the power station. Soils are saline and alkaline, and have similar composition at both sites.

The length as well as dry weight of root and shoot, leaf number and leaf area were observed in both the sites of sample. The leaf area was measured by a LI-3000A Leaf area meter (Li-cor, Lincoln, USA) and biomass by oven drying of samples at 80°C. The chlorophyll and carotenoid contents of fresh leaves were estimated by the method of Hiscox and Israelstam (1979) using dimetyhl sulfoxide (DMSO) and by applying the formulae of MacLachlan and Zalik (1963), and Duxbury and Yentsch (1956). Stomatal conductance, intercellular CO_2 concentration and net photosynthetic rate were measured by Infra Red Gas Analyser (LI 6200 portable photosynthesis system). Leaf gas exchange measurement were made on cloud-free days between 8.00-9.00 a.m. The level of significance of the variations observed was determined by the student 't' test.

RESULTS AND DISCUSSION

The data indicate that the population of *C. bonplandianum* growing in the vicinity of the power plant face a significant serious set back in their over all growth parameters studied (Table 1). Shoot length was more significantly affected (42%) than root length (17%).

The poor growth of *C. bonplandianum* could be due to translocation of SO_2 to meristematic region (Crittender and Read 1978). SO_2 may possibly slow down the rates of division and expansion of cells (Chang and Thompson 1966), leading to higher percent reduction in shoot length than root length. Root biomass showed a greater loss (85%) in comparison to shoot biomass (25%) and total biomass (54%). Greater loss in root biomass probably due to inhibition in translocation of photosynthates (Tingey *et al*. 1971, 1973, 1976, Shimizu *et al*. 1980) causing a remarkable reduction (82%) in root shoot ratio. Okano *et al*. (1984a,b) suggested that some gaseous pollutants alone and in combination can alter the normal allocation of dry matter within the plants and thus leaf growth is often favored at the expense of root growth. *C. bonplandianum* also exhibited a significant reduction in leaf number (11%), area leaf^{-1}(49%) and total leaf area (54%) in the polluted sites compare to control. Reduction in growth and development of root, shoot and leaf under the coal smoke-pollutants were also observed by earlier workers on *Solanum nigrum* (Ghouse and Khan 1984), *Gomphrena celosioides* (Khan and Khair 1985), *Melilotus indicus* (Ghouse and Saquib 1986), *Gnaphalium pensylvanicum* (Malabari *et al*. 1991), *Anagallis arvensis* (Saquib *et al*. 1992), *Brassica juncea* (Saquib and Khan 1999), *Datura innoxia* (Husen *et al*. 1999).

The net photosynthetic rate in leaves of *C. bonplandianum* decreased significantly by over 64% to control (Table 2). Reduction in photosynthesis due to coal smoke pollution is not unusual (Wali *et al*. 1997, Nighat *et al*. 1999, 2000). Ziegler (1972) has observed inhibition of photosynthesis by SO_3^{-2} due to competition between CO_2 and SO_3^{-2} for active sites on ribulose 1, 5-diphosphate carboxylase, the key enzyme for photosynthetic CO_2 fixation. A higher concentration of SO_3^{-2} resulted in non competitive inhibition of the enzyme. White *et al*. (1974) have observed inhibition of net photosynthesis in *Medicago sativa* exposed to SO_2 concentration greater than 0.2 ppm. The net photosynthesis was significantly reduced in *Pisum sativum* plant exposed to 0.025 ppm SO_2 (Bull and Mansfield 1974) and *Vicia faba* plant exposed to 0.035 ppm SO_2 (Black and Unsworth 1979). The decline in net photosynthetic rate due to pollutants may be via damage to the intersystem electron transport (Ishibashi *et al*. 1997) or decrease in PEP activity and concentration as a result of hydrolysis and mobilization from leaves (Joshi *et al*. 1993). Reduction in leaf areas could be also an additional factor contributing to the decline in net photosynthesis rate per plant (Table 2).

Table 1. Comparative data on morphological parameters obtained from the normal and polluted sample of *Croton bonplandianum*.

Parameters	**Control Mean ± SD**	**Polluted Mean ± SD**	**Percent Variation**
Root Length (cm)	17.60±2.70	14.63±3.07	-17*
Shoot length (cm)	44.10±11.20	25.50±4.60	-42**
Leaf Number Plant^{-1}	132.80±14.70	118.0±8.95	-11*
Area Leaf^{-1} (cm^2)	10.20±1.70	5.17±0.75	-49**
Total Leaf Area Plant^{-1} (cm^2)	1340.5±205.0	611.6±85.89	-54**
Root Biomass (gm)	2.81±1.10	0.43±0.08	-85**
Shoot Biomass (gm)	5.53±1.17	4.15±0.47	-25**
Total Biomass (gm)	8.34±0.91	5.53±1.17	-45**
Root Shoot Ratio	0.57±0.26	0.10±0.02	-82**

Mean ± Standard Deviation **Significant ($P < 0.01$) *Significant ($P < 0.05$). Above data have been reduced to two decimal place after final calculations.

Table 2. Comparative data on physiogical parameters obtained from the normal and polluted sample of *Croton bonplandianum*.

Parameters	**Control Mean ± SD**	**Polluted Mean ± SD**	**Percent Variation**
Net Photo Synthetic Rate (μmol CO_2 $m^{-2}s^{-1)}$	7.56±2.0	2.69±1.5	-64
Intercellular CO_2 concentration (ppm)	450.25±35.50	369.15±32.20	-18
Stomatal Conductance (μmol $m^{-2}s^{-1)}$	0.72±0.06	0.22±0.02	-69
Chlorophyll a (mg g^{-1} fresh wt)	1.61±.0.02	0.17±0.04	-89
Chlorophyll b (mg g^{-1} fresh wt)	1.48±0.22	0.37±0.09	-74
Total Chlorophyll (mg g^{-1} fresh wt)	3.09±0.20	0.54±0.12	-83
Carotenoids (mg g^{-1} fresh wt)	0.98±0.02	0.78±0.1	-20

Mean ± Standard Deviation **Significant ($P < 0.01$). Above data have been reduced to two decimal place after final calculations.

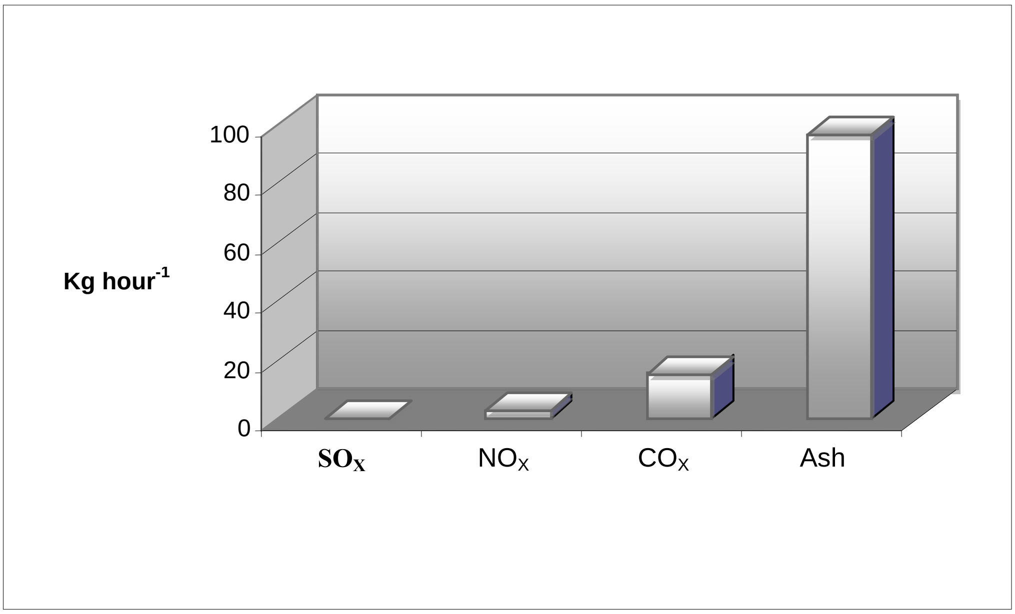

Fig. 1. Emission Rate of Pollutants.SO_X = Oxide of Sulphur, NO_X = Oxide of Nitrogen, CO_X = Oxide of Carbon in 10^5Kg hour^{-1}, and emission rate of ash in 10^3Kg hour^{-1} from the Thermal Power Plant. (Courtesy of Badarpur Thermal Power Plant, New Delhi).

Stomatal conductance and intercellular CO_2 concentration also decrease in plant exposed to BTPP pollution, the extent of decline being 69% and 18%, respectively (Table 2). An increase in the atmospheric CO_2 shifts the activity of ribulose 1,5-biphosphate carboxilase and oxygenase (Ribisco) in favor of carboxilation (Bowes 1991, Stitt 1991). Very high concentration of atmospheric CO_2 may depress the stomatal conductance (Morrison 1987, Field *et al*. 1995) which decrease the internal CO_2 concentration in leaves, thus causing a decrease in the net photosynthesis (Carison 1983, Bazzaz 1990). The photosynthetic activity also depends on pigment content. The pigment content including chlorophyll a, chlorophyll b, total chlorophyll and carotenoids decreased significantly in the polluted sample with percent variation having 89%, 74%, 83% and 20%, respectively (Table 1). The lower amount of chlorophyll a, chlorophyll b, total chlorophyll and carotenoids under the stressed environment were also noted in several other species (Singh *et al*. 1985, Singh *et al.* 1990, Malabari *et al*. 1991, Dhir *et al*. 1999, Nighat *et al*. 1999, 2000, Saquib 2008, Iqbal *et al*. 2010). In the present study Chlorophyll a was found to be more severely affected than chlorophyll b. Sulphite may react with chlorophyll to produce superoxide radicals (Shimazaki *et al*. 1980, William and Banerjee 1995). Chlorophyll a is degraded to pheophytin through replacement of mg^{+2} ions from chlorophyll molecules, but degradation of chlorophyll b by SO_2 leads the formation of chlorophyllide b due to removal of phytol group of the chlorophyll b molecules (Rao and Le Blank 1966). The sensitivity of chlorophyll a to air pollution is four and half times higher than carotenoides . The same results were also observed in *Calendula officinalis* (Singh *et al*. 1985) and *Dahlia rosea* (Ahmad *et al*. 1988) under the stress of SO_2.

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