Effect of Thermal Power Plant Emissions on Biomass and Chlorophyll Pigments of *Brassica juncea*

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***Abstract*—**This study evaluated the effect of thermal power plant emissions on biomass and chlorophyll pigments of *Brassica juncea var. T-59*, growing at 0.5, 2, 4, 6 and 20 Km distance leeward from a thermal power plant complex of Kasimpur (UP, India). Thermal power plant consumed 145.11×10^3 Kg h^{-1} of sulphur rich bituminous type of coal during winter season and emitted three major gases viz. oxides of sulphur (0.14×10^5 Kg hr^{-1}), nitrogen (2.58×10^5 Kg hr^{-1}) and carbon (23.38×10^5 Kg hr^{-1}) and fly ash (32.2×10^3 kg hr^{-1}). These effluents significantly reduced the shoot biomass, total biomass and chlorophyll pigments (chlorophyll a, chlorophyll b and total chlorophyll) up to a distance of 4 Km from the source of pollution except root biomass where the rate of reduction was significant up to a distance of 6 Km. The data indicates that the degree of response increased with decreasing distance from the source of pollution in comparison to the reference site 'E' situated at 20 Km. Root biomass suffered greater than shoot biomass and chlorophyll pigments. Biomass and chlorophyll pigments showed a significant and positive relationship with the distance from the source. Root biomass exhibited relatively greater degree of dependence (62%) on distance than total biomass (60%), Shoot biomass (57%), chlorophyll a (52%), total chlorophyll (50%) and chlorophyll b (45%) respectively.

***Keywords*—** Air pollution, *Brassica juncea*, biomass, chlorophyll.

I. Introduction

AIR pollution and particulate matters emitted as smoke from a thermal power plant causes environmental stress from the nearby vegetation and normally inhibiting the normal growth of the plants [1, 2, 3, 4, 5]. These effluents of the power plants emitted from elevated chimneys into the atmosphere from a plume, which ultimately reaches the ground at various distances and direction depending on the wind. The particulates and gaseous pollutants can cause synergistic or additive effects on the overall growth performance of the plants [6, 7, 8, 9, 10, 11].

The present report describes the effect of thermal power plant effluents on the biomass and chlorophyll contents of winter crops of Barssica juncea variety T- 59 growing at various distances from the source of pollution.

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II. Materials And Methods

The thermal power plant complex of Kasimpur consists of three power stations and located along the irrigation canal about 16 Km North- East of Aligarh (27° 58' N and 28° 3' N Latitude and 78° 8' E and 78° 93' E longitude and about 187 M above the sea level). The daily average of coal consumption in the whole complex during the winter season is about 145.11×10^3 Kg low-grade sulphur rich bituminous type of coal per hour. The amount of the three major gases viz. oxides of sulphur, Nitrogen and carbon dioxide and fly ash released from the power plant complex are shown in fig. 1.

Five sites were selected at about 0.5, 2, 6, 12 and 20 Km leeward from the above source of pollution, along the irrigation canal towards the south east direction where wind blow maximum in the year. The sites are identified as A, B, C, D and E respectively and fall in a track of soil which characterized by loam and clayey loam. The test plants were grown on these sites and irrigated and nourished with the basic dose of fertilizers (nitrogen, phosphorous and potassium) as recommended by Aligarh agricultural directorate. Site E was having apparently a negligible amount of air pollutants, served as reference site for comparison. Ten plants of 90 days old *B. juncea* were collected from each sites and compared their biomass (weighed in gm after oven dried at 80° C) and chlorophyll content (estimated according to Arnon [12]) with the reference site E. The data so obtained were analysed statistically. To obtain the relative degree of response of the biomass and chlorophyll pigments to coal smoke pollution, the per cent differences at sites 'A', 'B', 'C', 'D' compared with site 'E'(the reference site) were computed(Table I). The correlation coefficient and linear regression equation and per cent dependence of biomass and chlorophyll upon distance were also calculated (Table II).

III. Results

The Data recorded from the above studied indicates that the degree of loss in root, shoot and total biomass increased with decreasing distance from the source of pollution. The percent loss in root biomass was found to be statistically significant up to 6 Km while shoot and total biomass were significant up to 4 Km in comparison to reference site 'E' situated at 20 Km far from the source of pollution. But the severity of loss in all the cases were more prominent at site ‘A’ than site ‘B’, ‘C’ and ‘D’ . However, the difference is not distinct in the statistical sense between site ‘A’, ‘B’ and ‘C’. Root biomass suffered greater loss (86%) than shoot biomass (83%) and total biomass (83%) in comparison to reference site ‘E’ (Table I). The percent loss in Chlorophyll a, Chlorophyll b and total chlorophyll followed the same trend as in case of shoot and total biomass of the plant. On Site ‘A’ chlorophyll a showed greater (30%) but marginal loss than chlorophyll b (27%) and total chlorophyll (28%) in comparison to reference site ‘E’ (Table I).The percent dependence of biomass and chlorophyll pigments upon distance from the power plant, the correlation coefficient, linear regression equation are all shown in Table II. The root biomass showed a relatively greater degree of dependence (62%) on distance than total biomass (60%), shoot biomass (57%), Chlorophyll a (52%), Chlorophyll b (45%) and total chlorophyll (50%) respectively. However, the total biomass showed 70% dependence on total Chlorophyll of the plant.

IV. Discussion

A marked reduction in chlorophyll pigments resulted a further reduction in the biomass of the plant were studied by a number of workers under the stress of air pollutants as in the present investigation. [10, 11, 13, 14, 15].The views differ on the mechanism of air pollution induced chlorophyll loss. According to Singh et al. [16] the total chlorophyll continues to decrease with increasing sodium Meta bisulphate ($Na_2S_2O_3$) concentration in tomato leaves. Chlorophyll a is thought to be degraded to phaeophytin under SO_2 affected by replacing Mg^{+2} ions from chlorophyll molecules. In chlorophyll b, SO_2 removes the phytol group of the chlorophyll b molecules [17]. It has been suggested that at pH 2.2-3.5, free H^+ ions are generated in the cell from splitting of HSO_3 into SO_3 and H^+, and displacing Mg^{++} from the tetrapyrol ring of chlorophyll molecules to degrade them into Phaeophytin molecules [18,19]. This photosynthetically inactive brown pigment does not help in continuing the normal photosynthesis process and causes the observed decrease in total chlorophyll of the leaf sample which ultimately resulted in the reduction of the biomass of root and shoot of the plant. The present observation shows that the percent loss in biomass due to air pollutants released from the thermal power plant is almost three times higher than the chlorophyll pigments at the vicinity. Since chlorophyll pigments play an important role in photosynthesis, its sensitivity hampers the biomass production. Earlier workers have suggested that chlorophyll a is more sensitive than chlorophyll b in a polluted atmosphere [4, 11, 13, 20]. But present data revealed that percent reduction in chlorophyll a and b is almost equivalent. This confirms to the earlier observation on the alfalfa leaves [8] and gladiolus [21]. In the present study a direct relationship exists between the loss of chlorophyll pigments and biomass with the distance, as noted by earlier workers [3.4.5,22,23,24].

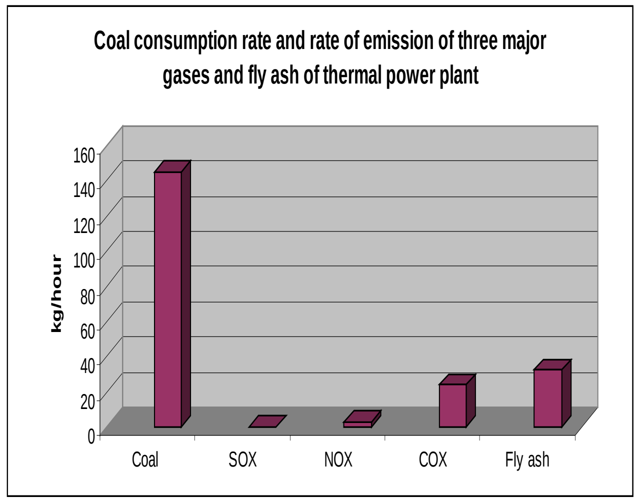

Fig. I Coal: Coal consumption rate x 10^3 Kg/h^{-1}, Sox: Oxides of Sulphur x 10^5 Kg/h^{-1}, Nox: Oxides of Nitrogen x 10^5 Kg/h^{-1}, Cox: Oxides of Carbon x 10^5 Kg/h^{-1} and Fly ash x10^3 Kg/h^{-1} (Source: Kasimpur Thermal Power Plant Complex)

Table I

Average Biomass (Root, Shoot And Total) And Chlorophyll Pigments (Chlorophyll A, Chlorophyll B And Total Chlorophyll) In The Population Of *Brassica Juncea* Of Varying Distance From Pollution Source. The Data Within Parenthesis Indicates The Percent Variation Over Reference Site ‘E’

Sites Distance	A 0.5Km	B 2.0Km	C 4.0Km	6.0Km	E 20Km	LSD at 5% level
Root Biomass ($mg\ plant^{-1}$)	a 1.3±0.3 (-86)	a 1.8±0.4 (-80)	a 2.4±0.5 (-74)	b 7.8±1.5 (-17)	c 9.4±2.9	1.25
Shoot Biomass ($mg\ plant^{-1}$)	a 14.4±3.1 (-83)	a 15.3±3.0 (-82)	a 17.0±2.9 (-80)	b 75.5±14.7 (-10)	b 84.2±25.3	11.0
Total Biomass ($mg\ plant^{-1}$)	a 15.7±3.0 (-83)	a 17.1±3.0 (-81)	a 19.4±2.9 (-79)	b 83.3±14.7 (-11)	b 93.6±23.7	12.3
Chlorophyll a (mg^{-g} fresh leaves)	a 0.63±0.02 (-30)	ab 0.68±0.04 (-25)	b 0.69±0.06 (-23)	c 0.84±0.03 (-6)	c 0.90±0.14	0.06

Chlorophyll b (mg^{-g} fresh leaves)	a 0.93±0.06 (-27)	a 0.96±0.13 (-25)	a 0.98±0.09 (-22)	b 1.25±0.08 (-2)	b 1.28±0.19	0.10
Total Chlorophyll (mg^{-g} fresh leaves)	a 1.56±0.07 (-28)	a 1.63±0.15 (-25)	a 1.69±0.14 (-22)	b 2.09±0.08 (-4)	b 2.18±0.30	0.15

Mean ± Standard deviation
LSD: Least significant Difference at 5% level
Figures with the same suffix are not significantly different ($p > 0.05$) from each other.
Above data have been reduced to one decimal place after final calculation.

TABLE II: CORRELATION COEFFICIENT (R), PERCENT DEPENDENCE (%D) AND LINEAR REGRESSION EQUATION ($\hat{Y}$) OF BIOMASS AND CHLOROPHYLL PIGMENTS UPON THE DISTANCE AND BETWEEN THE TOTAL CHLOROPHYLL PIGMENTS AND TOTAL BIOMASS.

Parameters	Correlation Coefficient(r)	Percent Dependence (%)	Linear regression equation($\hat{Y}$=a+bx)
Root Biomass & Distance	$0.79^{**} \pm 8.90$	62	$\hat{Y}$= 01.86 + 0.41x
Shoot Biomass & Distance	$0.76^{**} \pm 8.00$	57	$\hat{Y}$= 17.40 + 3.70x
Total Biomass & Distance	$0.77^{**} \pm 5.50$	60	$\hat{Y}$= 19.20 + 4.10x
Chlorophyll a & Distance	$0.72^{**} \pm 0.10$	52	$\hat{Y}$= 00.73 + 0.01x
Chlorophyll b & Distance	$0.67^{**} \pm 0.11$	45	$\hat{Y}$= 00.97 + 0.02x
Total Chlorophyll & Distance	$0.71^{**} \pm 0.08$	50	$\hat{Y}$= 01.63 + 0.03x
Total Chlorophyll & Total Biomass	$0.84^{**} \pm 0.08$	70	$\hat{Y}$=-143.06+103.29x

r ± standard error ** = significant at 1% level

REFERENCES

[1] F.Nighat, Mabmooduzzafar, M. Iqbal, Foliar responses of *Peristrophe bicalyculata* to coal smoke pollution, *J. Plant Biol*, vol. 42, pp. 205-212, 1999.

[2] N.Singh, A.Gayoor, W.Y Soh and M. Iqbal, Growth responses and Hyoscyamine content of *Datura innoxia* under influence of coal smoke pollution, *J. Plant Biol*, vol.43, pp. 69-75, 2000.

[3] M. Saquib, Root Growth Responses of *Melilotus indicus (L.) ll*. (Papilionaceae) of tropical agroecosystem to air Pollution, *Ecoprint*, vol. 16, pp. 29-34, 2009.

[4] M. Saquib, A. Ahmad, and K. Ansari, Morphological and physiological responses of *Croton bonplandianum Baill*. to air pollution, *Ecoprint*, vol. 17, pp. 35-41, 2010.

[5] M. Saquib, Root Growth Responses of *Anagallis arvensis* of the Tropical Agroecosystem to Coal Smoke Pollution, *IJBBB*, vol. 2, pp. 17-20, 2012.

[6] M. Agrawal, P. K. Nandi and D. N. Rao, Effect of Ozone and Sulphur dioxide pollutants separately and in mixture of chlorophyll and carotenoid pigments of *Oryza sativa*, *Water, Air and Soil Pollut*, vol. 18, pp. 449-445, 1982.

[7] M. Agrawal, P. K. Nandi, and D.N.Rao, Ozone and Sulphur dioxide effects on *Panicum miliaceum* plants, *Bull. Torrey Bot. Club*, vol. 110, pp. 435-441, 1983.

[8] N.Singh, and D. N. Rao, Studies of the effects of sulphur dioxide on alfalfa plants especially under condition of natural precipitation. *Indian J Air Pollut Contr* , vol.3, pp.1-8, 1980.

[9] F.A.Khan and N.R.Usmani, Effect of Sulphur dioxide on chlorophyll in Mustard leaf, *J Ind. Bot. Soc*, vol.67, pp. 205-208, 1988.

[10] N.Kumar, Response of *Vigna radiata* to SO_2 and NO_2 pollution, *Act. Bot. Indica*, vol.14, vol. pp.139-144, 1986.

[11] B.Wali, Mahmooduzzafar and M. Iqbal, Plant growth, stomatal response, pigments and photosynthesis of *Althea officinalis* as affected by So_2 stress, *Ind. J.Plant Physiol*, vol. 9, pp. 224-233, 2004.

[12] D.I.Arnon, Copper enzyme in isolated chloroplasts, Polyphenoloxidase in *Beta vulgaris*, *Plant Physiol*, vol. 24 pp. 1-15, 1949.

[13] N.Singh and D.N.Rao, Influence of sulphur dioxide on the growth and productivity of *Phaseolus aureus* plants, *Acta Bot. Indica*, vol. 14, pp. 230-235, 1986.

[14] B. Dhir, Mahmooduzzafar, T. O. Sodium, and M. Iqbal, Stomatal and photosynthetic responses of *Cichorium intybus* leaves to sulphur dioxide treatment at different stages of plant development, *J. Plant Biol*, vol. 44, pp. 97-102, 2001.

[15] A.A.Malabari., Z. Ahmad and M. Saquib, Effect of air pollution on *Gnephalium pensylvanicum willd*- a cropland Weed, *Geobios*, Vol. 18, pp. 7-10, 1991.

[16] S.N.Singh, M.Yunus and, N.Singh, Effect of sodium metabisulphite on chlorophyll, protein and nitrate reductase activity of tomato, *Sci. total Environ*, vol.81, pp. 269-274, 1990.

[17] D.N.Rao and Le Blanc, Effect of sulphur dioxide pollution on the lichen algae, with special reference to chlorophyll, *Bryologist*, vol. 69, pp. 69-65, 1966.

[18] W.Swannapinunt and T.T.Kozlowski, Effect of sulphur dioxide on transpiration, chlorophyll content, growth and injury in young seedlings of woody angiosperms, *Can. J. For. Res*, vol. 10, pp. 178-181, 1980.

[19] K.I.Shimazaki, T. Sakaki, D. Kondo and K. Sugahara, Active O_2 participation in chlorophyll destruction and lipid peroxidation in SO_2 fumigated leaves of spinach, *Plant cell Physiol* , vol.21, pp. 1193-1204, 1980.

[20] S.N.Singh, M.Yunus, K.Srivastava, K.Kulshreshtha, and K.J Ahmad, Response of *Calendula officinalis* L to long-term fumigation with SO_2., *Env. Pollut*, vol.39 pp. 17-25, 1985.

[21] N.Singh, S.N.Singh, K. Srivastava, M. Yunus , K.JAhmad, S.C.Sharma and A.N. Sharga, Relative sensitivity and tolerance of some gladiolus cultivars to sulphur dioxide, *Ann Bot*, vol. 65, pp 41-44, 1990.

[22] B.Lal and R.S Ambasht, Fluoride accumulation in a deciduous forest tree species in the neighborhood of an aluminium Factory, *Indian J. Forestry*, vol. 4, pp. 261-264, 1981.

[23] P. S. Dubey and K. Pawar, Air Pollution and plant response center. In: *Perspectives in environmental botany*. Vol. 1, ed. By D. N Rao, K.J. Ahmad, M.Yunus and S. N. Singh, Lucknow, Print House, India, 1985, pp. 101-118.

[24] F.A.Khan and A.K.M.Ghouse, Root growth responses of *Anagallis arsenic* L., Primulaceae to air Pollution, *Environ Pollut*., vol. 52, pp. 281-288, 1988