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Effect of Air Pollution on Root Growth and Productivity of *Anagallis Arvensis*

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Abstract. The effect of coal smoke pollution on the root length, root biomass and net primary productivity of *Anagallis arvensis* growing in association with wheat cropland were studied at monthly intervals from the four selected sites situated at 0.5, 2, 4 and 20 Km leeward from a thermal power plant complex. The degree of loss in the root growth of *A. arvensis* increased significantly with decreasing distance from the source of pollution. The trend of loss in the root length were similar at seedling (January) and middle (February) stages while, the adverse effect of pollutants extended to an equal extent up to 4 Km at old stage (March) of growth in comparison to the reference site 'D' situated at 20 Km leeward from the source of pollution. Root biomass suffered considerably at seedling stage up to 4 Km. However, the trend of loss was almost similar at middle and old stages of growth. Root biomass and net primary productivity showed a maximum loss (-45.8% to -74% and -53.8% to -76.9% respectively) at middle stage, may be due to high coal consumption and greater release of gaseous pollutants from the power plant. The percent loss in the root growth of *A. arvensis* showed a linear relationship with the distance of the site from the source of pollution at any given stage. Root biomass exhibited a relatively greater degree of dependence (59% to 76%) on distance than root length (38% to 58%).

Keywords: Air Pollution. Root Growth, Net Primary Productivity, *Anagallis arvensis*, Wheat cropland.

1. Introduction

The current widespread use of coal in the thermal power plant has contributed sizeably to degradation of the atmosphere. India has as many as 75 thermal power stations, running on sulphur-rich low grade bituminous coal and releasing enormous amounts of the oxides of sulphur, nitrogen and carbon, various other gases in small quantities, and particulates [1]. The pollutants emitted from the power plants reach to the ground at various distances depending upon the wind direction. The particulates and gaseous pollutants, alone and in combination, can cause serious setbacks to the overall physiology of plants [2, 3, 4, 5 and 6].

The sensitivity of roots has been studied by a number of workers under the stress of air pollution [7, 8, 9, 10, 11 and 12]. The present study examines the root growth responses of *Anagallis arvensis* of tropical agroecosystem to air pollution.

2. Materials and Methods

The Kasimpur Thermal Power Plant complex was selected as a source of pollution in the present study. It consists of three power stations with capacity of 90 MW, 210 MW and 230 MW electricity generation capacities. It is located along an irrigation canal about 16 Km north-east of Aligarh city (India). Geographically the Aligarh districts falls between $27^{o}29'$N and $28^{o}11'$ N latitude and$77^{0}29'$ E and $77^{0}38'$ E longitude at about 187 meters above the sea level. The coal consumption and amount of oxides of Sulphur, Nitrogen and Carbon released from the power plant complex are shown in Fig.1a&b.

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Four sites of the wheat crop fields were selected at about 0.5, 2, 4 and 20 Km leeward from above source of pollution along the irrigation canal side in the down stream direction since the wind predominantly blows in this direction for most part of the year. The sites are identified as namely ‘A’, ‘B’,’C’ and ‘D’ respectively and located in a belt of similar edaphic factors as well as ecological and agricultural conditions were selected for the present study. The soil is composed of loam and clayey loam at different study sites, has a high p^H and a poor drainage system. The area experienced a dry and tropical monsoon type of climate.

Ten samples of *Anagallis arvensis* were collected arbitrarily from a wheat crop land (at seedling to mature stage) of the four selected sites at monthly intervals (from January to March). The roots were washed and measured on a meter scale, oven dried at 80^0C for 48h, and weighed. The data so obtained were analyzed statistically. To obtain the relative degree of response the root length and root biomass, at a given growth stage, the per cent differences at sites ‘A’, ’B’, and ’C’ compared with site ’D’ (the reference site) were computed (Table 1 & 2). The net increase in biomass per root at any stage was divided by the age of the plant to obtain the net primary productivity (mg $root^{-1}day^{-1}$). However, the biomass of fine root hair lost during the measurement period was not included in this estimate of root productivity. Also plant age and initial biomass was taken to be zero on first January.

3. Results

The data obtained on average root growth of *A. arvensis* showed a gradual increase with increasing distance from the power plant (Table 1 & 2). The population of *A. arvensis* suffered significantly in all the three stages of growth up to 4 Km from the source of pollution as compared to the reference site ‘D’ situated at 20 Km away from the source. However, the severity of loss was more prominent at site ‘A’ in all the stages. The trend of loss in the root length was similar in both seedling (January) and middle stages (February) of growth. However, in the old stage (March) the adverse effect of pollutants extended to an equal extent up to 4 Km. Root biomass showed a considerable reduction up to 4 Km from the power plant at seedling stage. The trend of loss was similar in the middle and old stages of growth. However, the population was comparatively more sensitive in the middle stage (-45.8 to -74.7) of growth (Table 2). Root biomass suffered greater (-17.5% to -74.7.0%) than root length (-24.6 % to -54.5%). The percent loss in root growth of *A. arvensis* showed a linear relationship with the distance of the site from the source of pollution at any given stage.

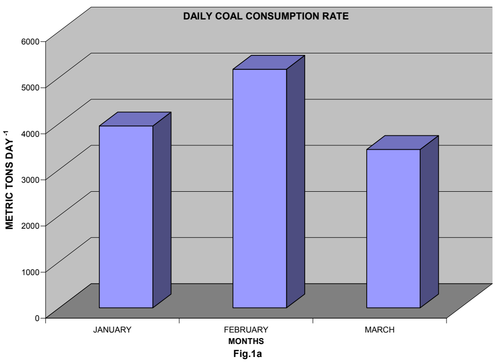
The data summarized in Table 3 show the daily net primary productivity in standing root biomass in time and space, and the percent loss at site ‘A’ , ‘B’ and ‘C’ compared with that at site ‘D’. Root productivity suffered considerably from seedling and middle stages growth up to a distance of 4 Km from the source of pollution. However, the degree of loss in the net primary productivity was found to be highest in the middle stage ((-53.8 to -76.9).

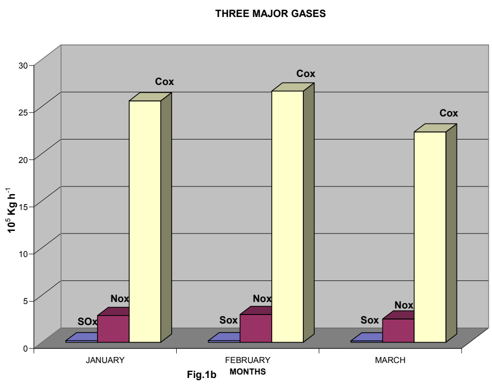
The percent dependence of root length and root biomass upon distance from the power plant, the correlation coefficient and linear regression equation are all summarized in Table 4. The root length and root biomass showed a significant, positive and high relationship with the distance from the source. Root length showed 38% to 58% dependence on the distance from the source, while the root biomass exhibited a relatively greater degree of dependence and varied from 59% to 76%. The correlation coefficient between the root length and distance, and root biomass and distance were found to be greater at old (March) and middle (February) stages respectively.

4. DISCUSSION

The present findings show that root growth in the species of *A. arvensis* differ in the degree of response with the distance of the power plant, with age of the plants and with coal consumption rate and the release of major gases from the power plant. The changes in the normal root growth have been found to be altered by air pollutants in other species were noted by number of workers [13, 14, 8, 15, 5, 11 and 12]. The effect on the root growth and development are ascribed to imbalance in carbon partitioning induced by air pollutants [16, 17]. In the present study the root length suffered greater in seedling stage (January) and middle stage(February) of growth while at old stage(March), it decreased to an equal extent up to 4 Km. [5] noted the root length of *Althea officinalis* decreased with the advancing of the age under the stress of SO_2. The percent reduction in root biomass and net primary productivity of *A. arvensis* increased from seedling to middle stages and decline at the old stage. [18] and [11] noted an increase in percent reduction in root growth from seedling to middle stage of growth of *Lolium prenne* and *Melilotus indicus* respectively under the stress of air pollutants.

A linear relationship exist between age and loss of phytomass caused by air pollution was noted in *Cicer arietenum* [19] and *Melilotus indicus* [11] .The highest degree of response in the middle stage of root biomass and Net Primary Productivity may be due to high amount of coal consumption and greater release of major gases from the power plant (See Fig.1a&b). Similar response under the coal smoke pollution was noted in a cropland weed of *Melilotus indicus* [11] and waste land weed of Anagallis *arvensis* [8]. The earlier workers [20, 21] noted a decrease in the extent of foliar injury and damage with the advancing distance from the source, as noted in the present study.





Sox= Oxides of Sulphur NOx= Oxides of Nitrogen COx=Oxides of Carbon
Source: Kasimpur Thermal Power Plant Complex

TABLE 1: Average root length plant^{-1} (cm) in the population of *Anagallis arvensis* of varying distance from pollution source. The data within parenthesis indicate the percent variation over reference site'D'.

Sites Distance	A 0.5km	B 2km	C 4km	D 20km	LSD at 5% level
January	a 2.0 ± 0.4 (- 54.5)	b 2.7 ± 0.5 (-39.6)	b 3.1 ± 0.8 (-30.3)	c 4.4 ± 1.1	0.7
February	a 3.1 ± 0.8 (-53.3)	b 4.3 ± 0.9 (-34.6)	b 5.0 ± 1.5 (- 24.6)	c 6.6 ± 1.8	1.2
March	a 4.8 ± 1.2 (- 44.2)	a 4.9 ± 1.1 (-42.7)	a 5.3 ± 1.2 (-38.3)	c 8.6±1.9	1.4

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.

TABLE 2: Average root biomass plant^{-1}(mg) in the population of *Anagallis arvensis* of varying distance from pollution source. The data within parenthesis indicate the percent variation over reference site 'D'.

Sites Distance	A 0.5km	**B 2km**	C 4km	D 20km	LSD at 5% level
January	a 1.2 ± 0.3 (- 69.2)	b 1.6 ± 0.4 (-57.0)	c 3.1 ± 0.6 (-17.5)	d 3.8 ± 0.6	0.4

February	a 2.8 ± 1.4 (-74.7)	b 5.0 ± 1.4 (-55.2)	b 5.3 ± 1.6 (- 45.8)	c 11.1 ± 2.1	1.5
March	a 3.2 ± 0.9 (- 71.7)	b 5.1 ± 1.0 (-54.9)	b 6.0 ± 1.8 (-46.9)	c 11.3 ± 2.4	1.6

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.

TABLE 3: Average daily net primary productivity (mg plant^{-1} day^{-1}) in the population of *Anagallis arvensis* of varying distance from pollution source. The data within parenthesis indicate the percent variation over reference site'D'.

Sites Distance	A 0.5 km	B 2 km	C 4 km	D 20 km
January	0.04 (-66.7)	0.05 (-58.3)	0.10 (-16.7)	0.12
February	0.06 (-76.9)	0.12 (-53.8)	0.08 (-69.2)	0.26
March	0.01 (+66.7)	0.003 (+50.0)	0.02 (+233.3)	0.006

Above data have been reduced to two decimal place for absolute values and to one decimal place for percent variation.

TABLE 4: Coefficient (r), percent dependence (d) and linear regression equation of Root Length and Root Biomass upon distance from the source of pollution.

Months	Parameters	Correlation coefficient (r)	Percent dependence (%d)	Linear regression equation ($\hat{Y}=a+bx$)
January	R L R B	0.74**±0.11 0.77**±0.10	55 59	2.33+0.11x 1.67+0.11x
February	R L R B	0.62**±0.13 0.87**±0.08	38 76	3.80+0.14x 3.50+0.39x
March	R L R B	0.76**±0.11 0.86**±0.08	58 74	4.58+0.20x 3.93+0.38x

R L: Root Length r ± standard error
R B: Root Biomass ** = significant at 1% level

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