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ROOT GROWTH RESPONSES OF *MELILOTUS INDICUS* (L.) ALL. TO AIR POLLUTION

Mohammad Saquib
Department of Biological Sciences
Kebbi State University of Science and Technology
Aliero, Kebbi State, Nigeria

ABSTRACT

The root length, root biomass and net primary productivity of *Melilotus indicus* were studied at the monthly intervals from a wheat cropland, growing at the four selected sites situated at 0.5, 2, 4 and 20 km leeward from the source of pollution caused by coal burning of a thermal power plant of Kasimpur (U.P, India). Root growth varied with the level of pollution, age of the stand and the coal consumption rate as well as the release of major gases from the power plant. The data indicate that the degree of response increased with decreasing distance from the source of pollution. The root length and root biomass were affected significantly at the 0.5 and 2 km. respectively in the seedling stage, while in the middle and old stages the loss significantly increased up to 4 km in comparison to the reference site situated at 20 km away from the source of pollution. The percent loss in the root growth of *M. indicus* increased from seedling to middle stage and decline at the old stage. Root length, root biomass and net primary productivity suffered greater in the middle stage, may be due to high coal consumption and greater release of gaseous pollutants from the power plant. The root length and root biomass showed a significant positive relationship with the distance from the source.

Key words: Air pollution, root growth, *Melilotus indicus*, wheat cropland, biomass.

INTRODUCTION

Environmental pollution and the energy crisis that mankind is facing are the outcome of urbanization and industrialization, as modern industrial development depends primarily on raw materials, energy, and transport. 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 (Iqbal *et al.* 2000). 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 (Tingey and Reinert 1975, Ashenden and Williams 1980, Dhir *et al.* 2001, Wali *et al.* 2004).

The sensitivity of roots has been studied by a number of workers under the stress of air pollution (Ghouse and Saquib 1986, Khan and Ghouse 1988, Saquib and Khan 1999). The present study examines the root growth responses of *Melilotus indicus* (Papilionaceae) of tropical agroecosystem to air pollution.

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. It is located along an irrigation canal about 16 km north-east of Aligarh city (India). Geographically the Aligarh district falls between $27^o 29'$ N and $28^o 11'$ N latitude and $77^o 29'$ E and $77^o 38'$ E longitude at about 187 m 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 Figs. 1 and 2.

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 were 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 pH and a poor drainage system. The area experienced a dry and tropical monsoon type of climate.

Ten samples of *Melilotus indicus* were collected randomly from a wheat crop land (at seedling to mature stage) from 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 (Tables 1 and 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 hairs 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.

RESULTS

The data indicate that the root growth of *M. indicus* gradually increased with increasing distance from the source of pollution (Table 1). A significant reduction in the root length and root biomass was found at 0.5 km and up to 2 km, respectively at the seedling stage (January), while in the middle stage (February) and old stage (March), the loss was significantly increased up to a distance of 4 km in comparison to the reference site 'D' situated at 20 km away from the source of pollution in both the parameters. However, the severity of loss was more prominent at site 'A' in all the stages. Root biomass suffered greater (5.6% to 87.2%) than root length (1.1% to 60%) (Table 2). The percent loss in growth of *M. indicus* showed a linear relationship with the distance of the site from the source of pollution at any given stage. The root length and root biomass were more affected by pollutants at the middle stage followed by old stage and seedling 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 (5.8% to 71%) to middle stage (40.3% to 95.6%) up to a distance of 4 km from the source of pollution, while it declined in the old stage (52.4%) at the 0.5 km.

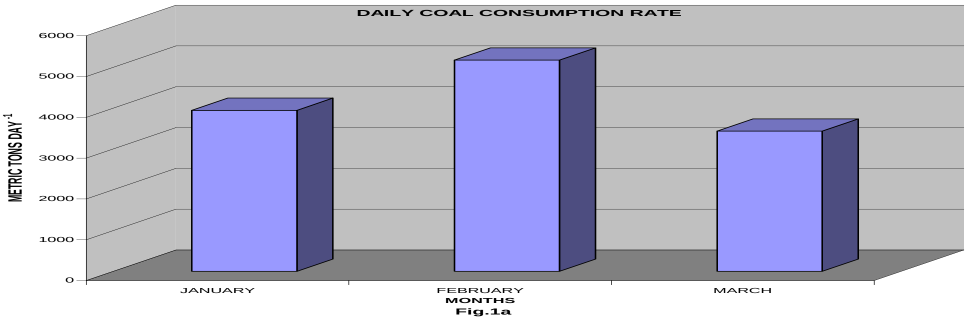

Fig. 1. Daily coal consumption rate in Kasimpur Thermal Power Plant Complex.

Source: Kasimpur Thermal Power Plant Complex

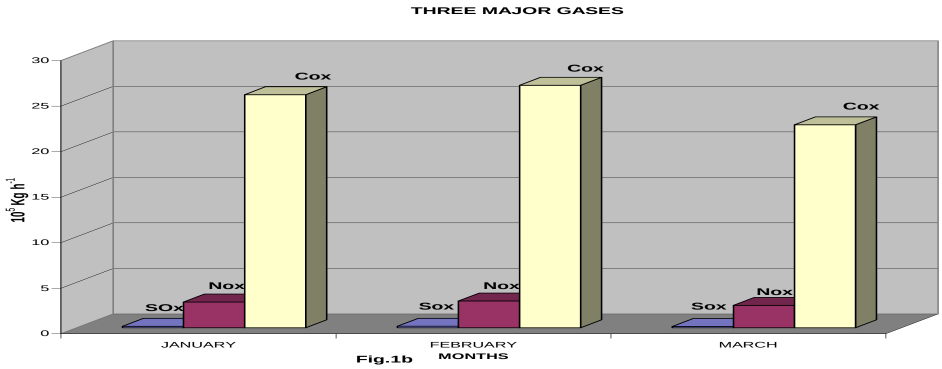

Fig. 2. Gases (Sx=Oxides of Sulphur, NOx=Oxides of Nitrogen, COx=Oxides of Carbon) released by the Kasimpur Thermal Power Plant Complex.

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 and positive relationship with the distance from the source. The degree of relationship, however, increased from seedling to middle stage and decline at the old stage. Root length showed 19 to 66% dependence on the distance from the source, while the root biomass exhibited a relatively greater degree of dependence and varied from 46 to 67%. The correlation coefficient between the root growth and distance were highest in the middle stage followed by old stage and seedling stage.

DISCUSSION

The data obtained in the present study clearly indicate that root growth of *M. indicus* 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 in other species were noted by a number of workers under the stress of air pollution (Mejstrik 1980, Swannapinunt and Kozlowski 1980, Khan and Ghouse 1988, Kumar 1986). The effect on the root growth and development are ascribed to imbalance in carbon partitioning induced by air pollutants (Tingey *et al.* 1991, Khan and Khan 1993). The loss at the seedling stage of the root length of *M. indicus* was confined at 0.5

km while in root biomass was limited within a distance of 2 km from the source and extended further to a distance of 4 km in later stage of growth in both the parameters. This development in the level of sensitivity at farther sites may be associated with increased cumulative doses of air pollutants in subsequent stages of growth. The present reduction in the root growth is increased from seedling to middle stage of growth of *Lolium perenne* under the stress of SO_2 (Bell *et al.*, 1979) and black gram under the stress of Ammonia showed a greater degree of loss, which declined in the more advanced stage.

A linear relationship between age and loss of phytomass caused by air pollution was noted in *Cicer arietenum* by Dubey and Pawar (1985).The highest degree of response in the middle stage may be due to high amount of coal consumption and greater release of major gases from the power plant. Similar response under the coal smoke pollution was noted in a waste land weed of *Anagallis arvensis* by Khan and Ghouse (1988). The earlier workers (de Ong 1946, Lal and Ambasht 1981) noted a decrease in the extent of foliar injury and damage with the advancing distance from the source, as noted in the present study.

Table. 1. Average root length plant^{-1} (cm) in the population of *Melilotus indicus* 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**	**LSD at 5% and 1% level**
January	3.3 ± 0.4a (- 27.7)	4.0 ± 0.5ab (-11.9)	4.5 ± 0.7b (-1.1)	4.6 ± 0.7b	1.0 and 1.4
February	4.1 ± 0.6a (-60.0)	6.4 ± 1.0b (-37.0)	7.8 ± 1.0b (- 23.6)	10.2 ± 1.3c	1.7 and 2.3
March	4.7 ± 0.7a (- 52.4)	6.6 ± 1.0b (-32.8)	7.9 ± 1.1b (-19.7)	10.3±1.4c	1.4 and 1.9

Mean ± Standard deviation, LSD: Least significant Difference at 5% and 1% 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 2. Average root biomass plant^{-1}(mg) in the population of *Melilotus indicus* 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**	**LSD at 5% and 1% level**
January	4.8 ± 0.6a (- 70.4)	6.6 ± 0.9b (-59.1)	15.2 ± 1.8c (-5.6)	16.1 ± 1.8c	1.7 and 2.3
February	6.1 ± 0.8a (-87.2)	25.6 ± 3.1b (-46.7)	32.6 ± 4.4c (- 32.3)	48.1 ± 7.0d	4.9 and 6.6
March	7.4 ± 1.0a (- 85.6)	21.4 ± 2.5b (-58.7)	44.7 ± 5.2c (-13.8)	51.8 ± 8.4d	4.6 and 6.2

Mean ± Standard deviation, LSD: Least significant Difference at 5% and 1% 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 3. Average daily net primary productivity (mg plant^{-1} day^{-1}) in the population of *Melilotus indicus* of varying distance from pollution source. The data within parenthesis indicate the percent variation over reference site 'D'.

Sites Distance	**A**	**B**	**C**	**D**
	0.5 km	**2 km**	**4 km**	**20 km**
January	0.15	0.21	0.49	0.52
	(-71.0)	(-59.6)	(-5.8)	
February	0.05	0.68	0.56	1.14
	(-95.6)	(-40.3)	(-50.9)	
March	0.04	0.13	0.39	0.12
	(-66.7)	(+8.3)	(+225)	

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

Table 4. Correlation 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	0.44**±0.15	19	3.8+0.04x
	R B	0.68**±0.12	46	7.5+0.47x
February	R L	0.81**±0.10	66	5.5+0.25x
	R B	0.82**±0.09	67	17.2+1.64x
March	R L	0.77**±0.10	60	5.8+0.21x
	R B	0.75**±0.11	57	19.6+1.72x

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

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