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Original Research Paper

Effect of Ambient Air Pollution on Photosynthetic Pigments of *Litchi chinensis* near Muzaffarpur Thermal Power Station, Muzaffarpur, Bihar

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ABSTRACT

Urbanization and increased energy demand has resulted in deterioration of air quality and thermal power plants are the major contributor of air pollution. The plants act as a sink for the pollutants and can absorb particulate and other gaseous pollutants into their system, but they also have some limitation and thus changes in their essential components that tend to induced degradation in photosynthetic pigments after prolonged exposure. Litchi (*Litchi chinensis*) is the livelihood for millions of people as it provides both on-farm and off-farm employment of the district Muzaffarpur of Bihar and exposed to the Muzaffarpur thermal power station. The present study was carried out to assess the impact of thermal power plants on photosynthetic pigments of litchi plants at the adjoining areas. Sampling was done from five different sites of two to seven kilometre distances from the thermal power plant and measurements were taken for all the plant species spectrophotometrically. All the measured pigments were reduced in an exposed area compared with control site. There was a maximum reduction reported in Birpur village, four kilometres from the Thermal power plant, the chlorophyll content, either in individual or in total decreased by 33% (total) and 25% and 50% in Chl. *a* and Chl. *b* respectively.

INTRODUCTION

The litchi (*Litchi chinensis* Sonn.), a member of the Sapindaceae family, is one of the best fruit trees growing in the tropical and subtropical regions of the world. It originated in China and widely received by consumers of world because of its delicious taste and possible health benefits (Menzel 1983, Singh et al. 2013). It fetches a fancy price in the international markets in fresh as well as processed form. The high demand and the high prices paid for litchi, especially in the European market, has created new interest in growing of this fruit. India and China account for 91 percent of the world litchi production, but it is mainly marketed locally. The quality of litchi exported from India is considered to be the best. In India, at present, the area of this fruit under cultivation is 84,000 hectares and production is 594,000 metric tons (NHB 2015). Litchi being exacting in climatic requirement is confined to a few states with 78 percent of production recorded in Bihar. Bihar produces 45% of total litchi and occupies nearly 40% of the area in India (Pandey & Sharma 1989). In this state, litchi is the livelihood for millions of people as it provides both on-farm and off-farm employment. Small and marginal farmers get additional income from litchi plants in their homesteads, so its cultivation is the livelihood security for a large population of Bihar (Singh & Kumar 1988, Singh 1998). In this state, litchi is mainly cultivated in the districts of Muzaffarpur, Vaishali, Sitamarhi, West & East Chaparan, Darbhanga, Samastipur (Ray et al. 1984). Litchi is grown on 46 per cent of cultivable land in Muzaffarpur district, which on an average produces 1.5 lakh tonnes of the fruit

In the 21st century industrialization and urbanization, increase in energy demands have resulted in a profound deterioration of air quality in developing countries like India. Electricity demand in India has been increasing at an average rate of 8.8% per year in the past 35 years. Muzaffarpur thermal power station of Kanti Bijlee Utpadan Nigam Limited (KBUNL) is one of the power generation plants in Muzaffarpur district of Bihar. It is a joint venture of NTPC (65%) and Bihar State Power Generation Company Ltd. (35%), located at 90 km away from Patna, the capital of the Indian state of Bihar. First started in 1985, Muzaffarpur thermal power station has an installed capacity of 110 × 2 MW. Recent reports have shown that air and soil quality around Indian thermal power plants are deteriorating at a measurable rate (Sharma & Tripathi 2008, Krishnaveni et al. 2013). Thermal power plants are point sources of pollution with more or less definite pattern of pollution emission. Main pollutants are SO_2, NO_2, CO, hydrocarbons and fly ash, which cause gradual degradation of ecosystems. These pollutants when absorbed by the leaves cause a reduction in the concentration of photosynthetic pigments viz., chlorophyll and carotenoids, which directly affects the plant productivity.

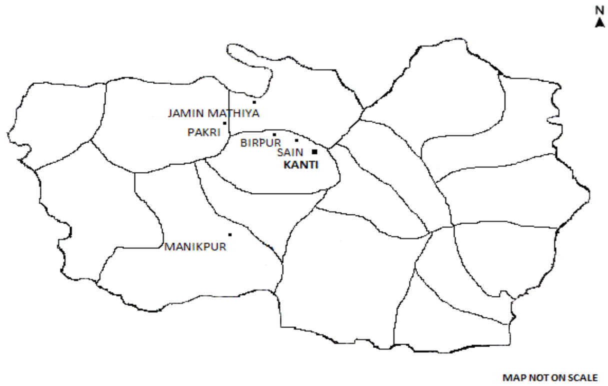

Fig. 1: Location of the study site with reference to Muzaffarpur district of Bihar.

Air pollution-induced degradation in photosynthetic pigments was also observed by a number of workers (Singh et al. 1990, Sandelius 1995). Rao & Leblanc (1966) have also reported a reduction in chlorophyll content brought by acidic pollutants like SO_2 which causes phaeophytin formation by acidification of chlorophyll. Several studies with higher plants exposed to different SO_2 concentrations show decrease in chlorophyll content (Inglisand Hill 1974, Hallgren & Huss 1975, De Santo et al. 1979, Agrawal & Rao 1982). Air pollutants like SO_2, NO_x, SPM and RSPM are responsible for reduction of biological and physiological responses of various plants and crops grown at polluted areas (Joshi & Chauhan 2008). In the last few years after establishment of the thermal plant at Kanti, it has been observed by the local cultivators that growth of plants and production of fruits deteriorating at the adjoining areas of six to eight kilometres. The present study was undertaken to analyse the effect of the thermal power plant and microclimate on the photosynthetic ability of *Litchi chinensis* as it is one of the widely grown crops of this area. According to prevailing wind direction, five study sites were selected at northwest of the thermal power plant. A control site was also selected at a distance of 7 km north of the plant and responses of plants to pollutants in terms of changes in chlorophyll were measured.

MATERIALS AND METHODS

Study area: The studies were conducted on plants growing in farmers' orchards under natural conditions. The plant samples were selected from different locations near to Muzaffarpur Thermal Power Station of district Muzaffarpur, situated at 26.12° N latitude, 85.4° E longitude and 47 meters elevation above the sea level.

Sample collection: The plant samples, the leaves of ten different orchards were collected from 10-12 years old and 10m height from the ground of the study site in triplicate (Fig. 1 and Table 1). The leaves were carefully removed from the bark, using a snapper blade and washed with water to remove the dust on the surface of the samples and collected in a sterile polythene bags, kept in liquid nitrogen and then transported to the laboratory immediately and were maintained at -200°C until further analysis.

Determination of chlorophyll content: About 0.2 g fresh leaves were cut and extracted overnight with 80% acetone at -4°C. The extract was centrifuged at 10,000 rpm for 5 minutes. The supernatant was saved and utilized for chlorophyll estimation. Absorbance of the supernatant was read at 645, 663 and 480 nm .The chlorophylls *a* and *b* contents were calculated by the following formulae as described by Arnon 1949.

Chlorophyll '*a*' (mg/L) = (0.0127) × (O.D.663) – (0.00269) × (O.D.645)

Chlorophyll '*b*' (mg/L) = (0.0229) × (O.D.645) – (0.00468) × (O.D.663)

Total chlorophyll (mg/L) = (0.0202) × (O.D.645) + (0.00802) × (O.D.663)

Statistical analysis: All experiments were carried out in triplicate and value expressed as mean ± SD.

RESULTS AND DISCUSSION

Chlorophyll is the principal photoreceptor in photosynthesis, the light-driven process in which carbon dioxide is "fixed" to yield carbohydrates and oxygen. The different pollutants play a significant role in inhibition of photosynthetic activity that may result in depletion of chlorophyll and pigments content of the leaves of various plants (Chauhan & Joshi 2008). The two way ANOVA shows that reductions in chlorophyll '*a*', chlorophyll '*b*' and total chlorophyll due to air pollution at different sites (Fig. 2 and Fig. 3). Chlorophyll *a* and *b* contents in the leaf samples of *Litchi chinensis* were reported as 1.28±0.02 mg g^{-1} and 0.56±0.03 mg g^{-1} respectively at control site Manikpur village, seven kilometre away from the thermal plant. It has been observed that the chlorophyll *a* and *b* contents at adjoining area of Kanti village at two kilometre from the thermal power plant were 1.02±0.03 mg g^{-1} and 0.41±0.07mg g^{-1} respectively, that reduced to 21% and 27% in Chl. *a* and Chl. *b* respectively, while the total reduction of Chl. reported was 23%. The Chl. *a* and Chl. *b* content were gradually decreased from Kanti village and reach to maximum reduction of 33% in total Chl. content and 25% and 50% in Chl. *a* and Chl. *b* respectively at Birpur village, four kilometres away from the thermal plant site, and the amount reported was 0.96±0.07 and 0.28±0.04 mg g^{-1} respectively. Total Chl. content was reported as

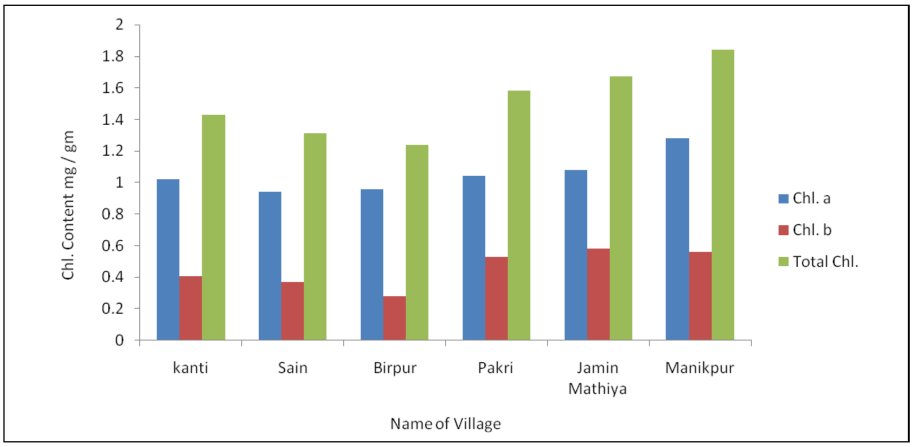

Fig. 2: Changes of Chl. *a*, Chl. *b* and total Chlorophyll content in *Litchi chinensis* due to thermal power plant emission.

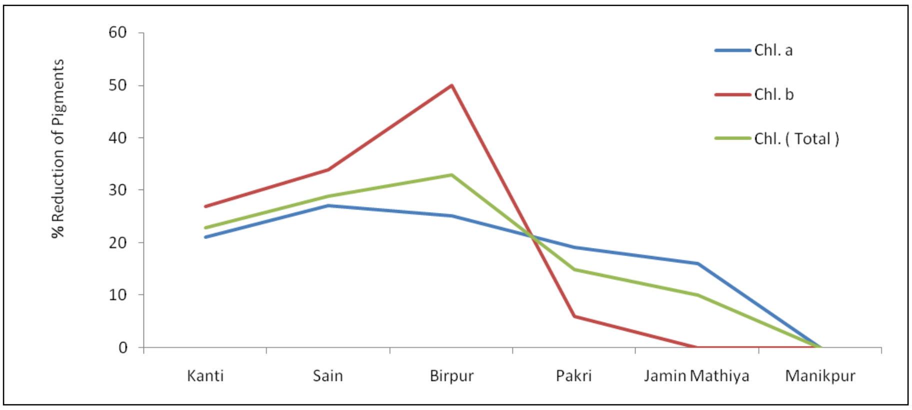

Fig. 3: Reduction of photosynthetic pigments Chl. *a*, Chl. *b* and total Cholophyll content in *Litchi chinensis* due to thermal power plant emission.

1.31±0.05 at Sain village, three kilometres away from the thermal plant, and reduces to 29% in total amount. The Chl. *a* and Chl. *b* content was 0.94 ±0.04 and 0.37±0.02 that reduces to 27% and 34% respectively. As maximum reduction was reported at Birpur village, the chlorophyll content, either in individual or in total increases by 8% (total) and 6% and 44% in Chl. *a* and Chl. *b* respectively from Birpur to Pakri village one kilometre away from the highly affected site and the amount reported was 1.58±0.04 (total Chl.) 1.04±0.04 (Chl. *a*) and 0.53±0.06 (Chl. *b*). It has been also observed that photosynthetic pigments further increased by 5% from Pakri to Jamin Mathiya one kilometre away from Pakri village and the amount reported was 1.08±0.05, 0.57±0.03 and 1.67± 0.02 in Chl.*a*, Chl.*b* and total chlorophyll respectively (Table 2). Chlorophyll pigments exist in a highly organized state, and under stress they may undergo several photochemical reactions such as oxidation, reduction, pheophytinisation and reversible bleaching (Puckett et al. 1973). Hence any alteration in chlorophyll concentration may change the morphological, physiological and biochemical behaviour of the plant. The reductions in chlorophyll *'a'*, chlorophyll *'b'* and total chlorophyll due to air pollution have been noted (Joshi & Chauhan 2008). Rao & Leblanc (1966) have also reported a reduction in chlorophyll content brought by acidic pollutants like SO_2, which causes phaeophytin formation by acidification of chlorophyll. Several studies with higher plants exposed to different SO_2 concentrations or long time accumulation of pollutants on leaf surface interrupting the sunlight availability to the leaf show decrease in chlorophyll content (Inglis & Hill 1974, Hallgren & Huss 1975, De Santo et al. 1979, Agrawal & Rao 1982). The results of this study reveal that there is a negative correlation between the distance from the thermal power plant and the chlorophyll contents.

CONCLUSION

On the basis of the study, it can be concluded that the physiology of litchi leaves is adversely affected and hence caus-

Table 1: Description of study area and sampling site.

Sl.No	Description of study area Sampling site		Distance from MTPC	Category	Age of plants
	Village	Block			
1	Kanti	Kanti	2 km	Polluted area	10-12 Yrs
2	Sain	Kanti	3 km	Polluted area	
3	Birpur	Kanti	4 km	Polluted area	
4	Pakri	Motipur	5 km	Polluted area	
5	JaminMathiya	Minapur	6 km	Polluted area	
6	Manikpur	Saraiya	7 km	Control	

Table 2**:** Concentration of Chlorophyll pigments (mg/g) in the leaves of *Litchi chinensis* collected from different studied area. All value expressed as the mean of three value ± SD.

Village	Chl. *a*		Chl. *b*		Total Chl. *a* and Chl. *b*	
	Amount (mg/g)	% Reduction	Amount (mg/g)	% Reduction	Amount (mg/g)	% Reduction
Kanti	1.02±0.03	21%	0.41±0.07	27%	1.43±0.08	23
Sain	0.94±0.04	27%	0.37±0.02	34%	1.31±0.05	29
Birpur	0.96±0.07	25%	0.28±0.04	50%	1.24±0.04	33
Pakri	1.04±0.08	19%	0.53±0.06	6%	1.58±0.04	15
JaminMathiya	1.08±0.05	16%	0.58±0.03	0%	1.67±0.02	10
Manikpur	1.28±0.02	Control	0.56±0.03	Control	1.84±0.07	Control

ing deterioration in the quality of economically important plant. It is proposed that a complete analysis of all the biochemical parameters be carried out in detail and also suggest the thermal power plant to use plants as screens or green belts to improve air quality.

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