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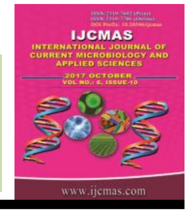

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Effect of Air Pollutants on Growth and Yield of Rice (*Oryza sativa*) and Wheat (*Triticum aestivum*) Crops around the Coal Based Thermal Power Plant

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A B S T R A C T

Presently, air pollution becomes apocalypse for living beings (human, animals and crops). Air pollutants have the potential to reduce both nutritional quality and yield of crops. Ten different locations were selected in the vicinity of Thermal Power Plant (TPP) (NTPC Dadri, Uttar Pradesh) to assess the impacts of particulate matter deposition on rice and wheat crops at a different distance within 1-8 km radius. The results indicated that aerial deposition on crop canopy was ranged from 0.85 to 1.88 mg/cm^2 in wheat and 0.54 to 1.44 mg/cm^2 in rice crop at vegetative stage and flowering stage deposition was 1.08 to 2.20 mg/cm^2 of wheat and 0.64 to 2.07 mg/cm^2 in rice. We found that effect of air pollutants on crops was maximum at 2-6 km area on the leeward side from NTPC and less impact on the windward side. The particulate matter deposition reduced the photosynthetic rate which leads to decrease in leaf area and transpiration rate in rice and wheat crops and finally had an adverse impact on crop yield. This leads to significant reduction in grain yield of 8.46% and 9.52% in rice and wheat and 11.08% and 12.24% reduction of straw yield in rice and wheat respectively. The maximum yield reduction was observed at Jharcha and Khangoda (most polluted sites) over Akilpur Jagir and Pyawali Tajpur (least polluted sites).

Introduction

Presently, air pollution is a burning problem for every part of the globe. More than 100 pollutants which pollute air have been identified. They may be in the form of solids, liquids or gases. They differ significantly from place to place depending upon the particular complex of contaminant source and atmospheric conditions. The air pollutants emitted from both natural as well as anthropogenic sources. The study conducted by the Central Pollution Control Board (CPCB), reveals that 77% of Indian urban agglomerations exceeded national ambient air quality standard (NAAQS) for suspended particulate matter (SPM). Estimates from the WHO suggest that 13 out of 20 cities in the world with the worst fine particulate (PM2.5) air pollution are in India, including Delhi, the worst-ranked metropolitan. Off late researchers, policy makers and governments have focused their attention on air quality in the urban areas only. Air quality in the countryside remains a neglected issue so far. The common belief is that the countrysideis free from air pollution. On the contrary, air quality in the countrysideall over the world and particularly in the developing countries may be more polluted than some of the urban areas. Rural areas suffer from outdoor as well as indoor air pollution contributed through small scale industries (brick kilns, jaggery producing industries), constructional activities, agrochemicals and burning of agriculture residue (Kumar *et al.,* 2016)

In the last three decades, however, changes in the pattern of air pollutant emissions, including increases in those from motor vehicles and TPP, have led to greater pollutant impacts in more remote rural areas. In developing countries, most of the emphasis was given on human health in metro cities. However, air pollution in urban and peri-urban areas could also have significant impacts on agricultural production. There are a large number of industries that are polluting the surrounding environment and having potential impacts on air quality and health of living beings. Currently, coal fired TPP contribute a major portion of the world's electricity generation. At present, coal is the principal energy source in India which is used for near about 62 % of electric power generation in the country. This situation will persist for several decades until alternative sources of energy are developed and exploited on a commercial scale (Ram *et al.,* 2007). Studies from different countries have shown a significant environmental impact of coal fired power plants with its surroundings (Alastuey *et al.,* 1999; Sharma *et al.,* 2005; Xie *et al.,* 2006). The primary emissions from coal combustion at TPPs are carbon dioxide, nitrogen oxides, sulfur oxides and airborne inorganic particles such as fly ash, soot and other trace gas species.

Air pollution has become a severe environmental stress to crop plants due to increasing industrialization and urbanization during last few decades.Air pollutants are not only affecting the health of people but also having large negative impacts oncrops. Air pollutants have the potential to reduce both yields as well as the nutritional quality of crop plants (Jager *et al.,* 1993; Ashmore and Marshall, 1999). A major threat to crop production is gaseous air pollutants, mainlysulfurdioxide, nitrogen dioxide, SPM and the secondary photochemical oxidant like ozone. These phytotoxic gases and particulates could have increasing adverse impacts on the livelihoods of farmers and consumers through affecting the agricultural production (Marshall *et al.,* 2001; TeLintelo *et al.,* 2002). In Indian cities' concentrations of phytotoxic air pollutants often exceed the thresholds of toxicity to vegetation (Pandey *et al.,* 1992; Stone *et al.,* 1992).

The particulates and gaseous pollutants, alone and in combination, can cause serious setbacks to the overall growth, physiology and biochemistry of crop plants (Ashenden and Williams, 1980; Mejstrik, 1980; Anda, 1986). A considerable amount of damage is caused to vegetation by the particulate matter showing the bodily harm of leaves as a result of dust deposition, inhibition of photosynthetic activities and protein synthesis as well as susceptibility to injuries caused by microorganisms and insects (Saha and Padhy, 2011). Dust effects on vegetation may be connected with the decrease in light available for photosynthesis, an increase in leaf temperature due to changed surface optical properties, and interference with the diffusion of gases into and out of leaves (Prajapati *et al.,* 2012). In the present study, the impact of air pollutants mainly particulate deposition on wheat and rice were observed in the vicinity of NTPC Dadri TPP in Uttar Pradesh at ten locations.

Materials and Methods

Study area

The study was conductedin the vicinity of NTPC Dadri. It is located in Gautam Budh

Nagar district of Uttar Pradesh (28°35′54″N & 77°36′34″E). The experiment was conducted during summer and winter seasons of 2015-16.During the summermonths maximum mean monthly temperature rangedfrom 33.4 to 39.9°C with minima from 24.5 to 28.3°C and during the winter months maximum temperatureranged from 21.1 to 30.3°C and minima from 7.6 to 15.1°C. The wind speed varied from 14.9 to 22.8 km h^{-1} during the summer and 10.1 to 17.3km h^{-1}during the winter. The wind direction was predominantly north westerly during the whole growing period (as shown in wind rose diagram, Fig. 1).

Study sites

Around the TPP, ten sites were selected according to dominant wind direction and distance from the power plant. Two control sites were identified towards the windward direction to the TPP (Akilpur Jagir, Pyawali Tajpur) at different distances from the TPP. Dominant wind direction throughout the year was in the north-west (NW). Near about four sites were selected in a leeward direction (Jarcha, Uncha Amirpur, Khangoda and Nagla Kashi), two were chosen perpendicular to dominant wind direction (Nidhauli and Ranauli Latifpur) and two in extreme north and south directions to the TPP (Tatarpur and Salarpur Kalan) (Table 1 and Fig. 2).

Experimental setup

The soil samples were collected from each site and analyze at the laboratory. Soil samples were analyzed for pH, EC, Nitrogen, Phosphorous, potassium, and soil organic carbon content. Soils were found to be alkaline with pH ranging from 7.57-8.81 and electrical conductivity (EC) ranging from 0.24-0.47 mmhos/cm. Total nitrogen content of soils varied from 0.062 to 0.085%, available phosphorus (P_2O_5) was 19.4 to 23.8kg/ha and available potassium (K_2O) ranged from 137.5 to 162.7 kg/ ha. Soil organic carbon content was 0.39 to 0.44%.

Mainly two crops (Rice and Wheat) were grown in the study area. Rice was grown from the month of July to October and the wheat crop was grown from the month of November to April.Farmers were mainly growing Pusa 1121 variety of rice and PBW 343 variety of wheat crop. Transplanting of rice seedlings was done during thesecondfortnight of July. Wheat sowing was done in the second week of November. Farmers field was selected which grown same crop variety and following almost similar crop management practices. Field visits were done at the monthly interval for recording growth, and yield parameters of rice and wheat plants during summer and winter. The farmer's fields were also continuously monitored for any other stresses like insect pest infestation and diseases during the growing season.

Soil parameters analysis

In the intial stage of experiment, we collected soil samples (0-15 cm) from selected sites. After that, samples were analyzed for various physic-chemical properties like organic carbon (Walkley and Black, 1934), pH (pH meter), EC (EC meter), available Nitrogen (Subbaiah and Asija, 1956), Phosphorous (Jackson, 1973) and Pottassium (neutral normal ammonium acetate method using a flame photometer). The analytical data quality was ensured through careful standardization, procedural blank measurements and duplicate sample.

Air quality analysis

The monitoring of the primary and secondary pollutants, i.e., NO_2, SO_2, PM10, TSP, O_3 were carried out as per the guidelines are given by Central Pollution Control Board

(CPCB). Particulate matter, SO_2, NO_2 and O_3wereanalyzed by the gravimetric method, Improved West and Gaeke method (1956), Jacob & Hochheiser modified method (1958) and a chemical method respectively.

Plant analysis

Photosynthesis rateand transpiration rate were observed at vegetative and flowering stages using portable Infra-Red Gas Analyzer (IRGA) (LI6400, LICOR, USA). Leaf samples were collected at the vegetative and flowering stage for determination of leaf area index (LAI). Leaf area was recorded by placing the fresh leaves of one hill flat in a digital leaf area meter (LI-3100, LiCor Inc., Lincoln, Nebraska). The area obtained was then divided by the area of ground to get LAI (Pask *et al.,* 2012). During harvesting of rice and wheat in October and April respectively, plant samples were collected from three representative locations of $1m^2$ area from each selected site. Biomass, as well as grain weight,were recorded and yield of both the crops was calculated.

Analysis of particulate matter deposition on crops plants

Deposition of particulate matter on crop canopy of wheat and rice was also measured as per the methodology of Prusty *et al.*, 2005. Leaf samples were randomly collected in a beaker and washed thoroughly by a hairbrush with distilled water. The water in the beaker was completely evaporated in an oven at 100°C and weighed.

The following equation quantified dust load:

$$W = (w_2 - w_1) / A$$

Where, W is the amount of dust load (mg/cm^2)' w_1 is initial weight of beaker with dust; w_2 is final weight of the beaker with dust; A is total area of the leaf (cm^2).

Statistical analysis

Significant differences of the mean between selected sites were statistically analyzed by one way ANOVA (at $p \leq 0.05$) using SAS software package 9.2.

Results and Discussion

Concentration of air pollutants

Air quality monitoring showed that concentration of TSP, SO_2, NO_2 and O_3 found minimum at Akilpur Jagir followed by Pyawali Tajpur (control sites), whereas maximum levelwas found at Khangoda followed by Jarcha, Uncha Amirpur village, due to their location in the leeward side to the TPP.TSP, SO_2 and NO_2 concentration were maximum in winter and minimum in the summer season, butO_3 concentration was maximum in summer and minimum in winter season due to the role of sunlight in the formation of ozone. Other villages had a concentration in between the maximum and minimum as shown in Tables 2 and 3. Agrawal *et al.,* (2003) also observed that higher air pollutants concentration at industrial area and concentration of TSP, SO_2 and $NO_2$was maximum in winter and O_3concentration in summer.

Aerial deposition of particulate matter at selected sites

Estimation ofan aerial deposition on crop canopy showed that in wheat crop, maximum deposition was found in Jarcha (1.88 mg/cm^2) followed by Khangoda (1.75 mg/cm^2) and Uncha Amirpur villages (1.67 mg/cm^2). The minimum deposition was found in Akilpur Jagir(0.85 mg/cm^2) followed by Pyawali Tajpur villages(0.98 mg/cm^2) at vegetative stage.The almost similar trend was also observed at flowering stage. In rice cropmaximum deposition was found in Jarcha (1.44 mg/cm^2) followed by Khangoda (1.42

mg/cm^2) and Uncha Amirpur villages (1.33 mg/cm^2) whereas minimum deposition was found in Akilpur Jagir (0.54 mg/cm^2) followed by Pyawali Tajpur villages(0.67 mg/cm^2) at vegetative stage.Again almost similar trend was also observed at flowering stage. In wheat crop atmospheric deposition load on leaves was found to be more than rice at both the stages. This is primarily due to that wheat is grown in the winter months when rainfall is much less than the Kharif season when rice grown. Higher rainfall in Kharif might have washed out some of the deposited particulate matter from rice leaves (Figs. 3 and 4). Earlier co-workers reported similar types of results. Chakrabarti *et al.,* (2014) reported that in wheat crop, atmospheric deposition load on leaves was found to be more than rice at all stages and deposition was gradually decreased with increasing distance from TPP.

Effect of air pollution on growth and physiological parameters of the crops

Photosynthetic rate

Air pollution significantly affected the physiological parameters of crpos. Cropsare grown leeward side were more affected than windward side. Photosynthetic rate and transpiration rate of rice was reduced with an increase in air pollutants. In rice crop maximum photosynthetic rate was found at Akilpur Jagir (12.57µmol/m^2/s) followed by Pyawali Tajpur (11.24µmol/m^2/s)those control sites whereas minimum was found at Khangoda (7.84µmol/m^2/s) followed by Jarcha (8.84µmol/m^2/s)those are situated leeward side of TPP at vegetative stage. Near about similar trend in photosynthesis rate in rice crop was also observed at flowering stage. In wheat crop maximum photosynthetic rate was found at Akilpur Jagir (17.98 µmol/m^2/s) followed by Pyawali Tajpur (17.15µmol/m^2/s) whereas minimum at Uncha Amirpur (8.17µmol/m^2/s) followed by Jarcha (8.67µmol/m^2/s). The almost similar trend in photosynthesis rate in the wheat crop was also observed at flowering stage (Figs. 3 and 4).

Transpiration rate

The maximum transpiration rate in ricewas found at Akilpur Jagir (12.55 mmol $H_2O/m^2/s$) followed by Pyawali Tajpur (11.87 mmol $H_2O/m^2/s$).Those are control sites whereas minimum was found at Uncha Amirpur (6.54 mmol$H_2O/m^2/s$) followed by Jarcha (7.32 mmol $H_2O/m^2/s$) those were situated leeward side of TPP at vegetative stage.Near about similar trend in transpiration rate in rice crop was also observed at flowering stage. The maximum transpiration rate in wheat was found at Akilpur Jagir (11.98 mmol $H_2O/m^2/s$) followed by Pyawali Tajpur (11.35 mmol $H_2O/m^2/s$) whereas minimum at Uncha Amirpur (5.88 mmol $H_2O/m^2/s$) followed by Khangoda (6.31 mmol $H_2O/m^2/s$) at vegetative stage. Almost similar results in wheat crop were also observed at flowering stage (Figs. 5 and 6). Raja *et al.,* (2014) reported that how different level of fly ash deposition affected the photosynthesis, transpiration rate and productivity of rice. He reported that Photosynthetic rate and transpiration rate of rice was reduced with increasing rate of fly ash deposition. The highest dose of fly ash deposition reduced the Photosynthetic rate up to 15.1 to 44.6 % over control at different growth stages and transpiration rate was decreased up to 11.3 to 44.4 % over control at various growth stages. Lehnherr *et al.,* (1988) and Darrall (1989) also reported similar types of results.

Effect of air pollution on Leaf Area Index (LAI)

Air pollution significantly hampered the growth and physiological parameters of the both crops rice and wheat. Leaf area index

(LAI) is directly correlated with photosynthesis rate, so a reduction in photosynthetic rate directly affects the LAI of the crops. After the measurement of LAI in both crops, we found that at flowering stage LAI was maximum at Akilpur Jagir (3.61) followed by Pyawali Tajpur (3.58) those were control sites. Whereas minimum at Jharcha (3.37) followed by Khangoda (3.41). In wheat crop maximum LAI was found at Akilpur Jagir (3.91) followed by Piyawali Tajpur (3.88), whereas minimum at Jharcha (3.34) followed by Khangoda (3.37).Near about Similar trend of LAI was observed in both crops at vegetative stage (Figs. 7 and 8).

Chakrabarti *et al.*, (2014) and Raja *et al.*, (2014) reported similar types of results that LAI significantly decreased with higher level of air pollution.

Table.1 Selected sites along with latitude and longitude

Village	Direction to NTPC	Aerial distance from TPP (km)	Latitude	Longitude
AkilpurJagir	NW	4.5	28.615427	77.562230
PyawaliTajpur	NW	2.5	28.609550	77.580426
Tatarpur	N	3.0	28.628311	77.604716
Salarpur Kalan	S	3.5	28.581064	77.598107
RanauliLatifpur	SW	4.0	28.579108	77.583039
Jarcha	SE	6.5	28.570963	77.651665
Khangoda	SE	3.5	28.590027	77.627510
UnchaAmirpur	SE	1.0	28.606024	77.610476
NaglaKashi	SE	8.0	28.585104	77.674442
Nidhauli	NE	3.0	28.618532	77.627541

Table.2 Seasonal mean NO_2 and SO_2concentrations (μg/m^3) during summer, Winter and monsoon seasons

Sites	NO_2 (μg/m^3)			SO_2 (μg/m^3)		
	Summer	Winter	Monsoon	Summer	Winter	Monsoon
AkilpurJagir	18.51 ± 0.96	19.4 ± 1.34	17.32 ± 0.52	8.98 ± 0.64	10.58 ± 0.93	7.54 ± 0.89
PyawaliTajpur	20.24 ± 2.08	20.28 ± 0.74	18.91 ± 0.71	10.81 ± 0.88	11.95 ± 1.14	8.96 ± 1.04
Tatarpur	24.11 ± 2.98	26.31 ± 3.7	21.45 ± 1.44	11.44 ± 0.89	13.52 ± 0.9	10.03 ± 0.5
Salarpur Kalan	22.63 ± 3.09	25.4 ± 2.1	20.72 ± 1.76	11.83 ± 0.79	13.76 ± 1.37	10.18 ± 0.78
RanauliLatifpur	24.50 ± 3.6	27.57 ± 2	22.93 ± 1.31	12.89 ± 0.3	14.58 ± 1.12	11.84 ± 1.2
Jarcha	38.53 ± 2.92	40.7 ± 3.31	34.59 ± 2.44	16.36 ± 1.19	19.95 ± 2.4	13.69 ± 1.97
Khangoda	37.35 ± 2.3	39.32 ± 1.99	34.27 ± 2.48	16.04 ± 2.01	18.58 ± 1.37	13.6 ± 1.75
UnchaAmirpur	32.09 ± 3.54	32.54 ± 1.2	29.89 ± 3.13	14.56 ± 1.07	16.47 ± 0.64	12.55 ± 1.7
Nagla Kashi	20.86 ± 4.24	25.79 ± 1.5	23.82 ± 5.39	11.97 ± 0.59	13.1 ± 0.6	10.62 ± 0.72
Nidhauli	23.56 ± 2.75	27.71 ± 2.71	22.04 ± 1.57	12.71 ± 1.23	14.37 ± 0.09	11 ± 1.09
LSD (P=0.05)	2.38	2.82	2.76	1.04	1.41	1.05

Table.3 Seasonal mean O_3 and TSPconcentrations ($\mu g/m^3$) during summer, Winter and monsoon seasons

Sites	Ozone (O_3) ($\mu g/m^3$)			Total suspended particulates (TSP) ($\mu g/m^3$)		
	Summer	Winter	Monsoon	Summer	Winter	Monsoon
Akilpur jagir	22.37 ± 4.88	16.98 ± 1.87	20.91 ± 1.38	352.75 ± 24.19	399.00 ± 12.88	351.25 ± 30.42
PyawaliTajpur	24.08 ± 5.21	18.62 ± 2.21	22.70 ± 0.95	370.25 ± 17.59	417.25 ± 20.45	374.00 ± 27.99
Tatarpur	25.62 ± 4.17	22.64 ± 2.24	26.94 ± 1.18	464.25 ± 20.11	484.25 ± 9.95	449.25 ± 14.08
Salarpurkalan	25.97 ± 3.46	22.91 ± 1.35	27.04 ± 1.89	465.25 ± 24.57	476.75 ± 11.18	443.50 ± 13.38
Ranauli Latifpur	26.84 ± 3.73	22.63 ± 1.49	25.95 ± 1.25	514.75 ± 37.04	537.75 ± 29.62	477.75 ± 14.97
Jarcha	32.57 ± 5.37	27.24 ± 2.90	32.74 ± 0.89	594.75 ± 35.26	623.50 ± 18.63	548.75 ± 26.73
Khangoda	31.97 ± 3.95	26.87 ± 2.25	31.67 ± 1.70	583.75 ± 43.02	615.25 ± 14.22	538.00 ± 36.04
Uncha Amirpur	29.73 ± 3.54	25.69 ± 2.39	31.08 ± 1.58	572.75 ± 43.28	591.50 ± 18.86	524.75 ± 35.66
Nagla Kashi	34.13 ± 6.22	27.05 ± 3.64	31.74 ± 2.38	538.25 ± 32.44	542.00 ± 17.57	530.00 ± 9.83
Nidhauli	26.91 ± 3.98	24.64 ± 3.93	27.15 ± 2.01	516.75 ± 26.47	549.50 ± 13.82	498.25 ± 13.72
LSD (P=0.05)	2.19	1.66	1.29	20.01	21.76	24.66

Table.4 Grain and straw yield of rice and wheat crops grown at selected sites

Sites	**Grain yield (t/ha)**		**Straw yield (t/ha)**	
	Rice	**Wheat**	**Rice**	**Wheat**
Akilpur jagir	$3.37^{a} \pm 0.03$	$4.57^{a} \pm 0.03$	$6.77^{a} \pm 0.04$	$8.67^{a} \pm 0.08$
Pyawali tajpur	$3.32^{ab} \pm 0.05$	$4.51^{ab} \pm 0.04$	$6.42^{b} \pm 0.03$	$8.56^{b} \pm 0.06$
Tatarpur	$3.24^{bc} \pm 0.09$	$4.44^{bc} \pm 0.04$	$6.39^{c} \pm 0.06$	$8.32^{c} \pm 0.03$
Salarpur kala	$3.17^{dfe} \pm 0.04$	$4.37^{c} \pm 0.05$	$6.32^{d} \pm 0.06$	$8.40^{d} \pm 0.1$
Ranauli latifpur	$3.22^{cd} \pm 0.06$	$4.35^{d} \pm 0.09$	$6.22^{ef} \pm 0.09$	$8.21^{e} \pm 0.06$
Jarcha	$3.05^{f} \pm 0.07$	$4.19^{e} \pm 0.08$	$6.07^{h} \pm 0.08$	$7.84^{h} \pm 0.05$
Kangoda	$3.08^{ef} \pm 0.04$	$4.17^{e} \pm 0.06$	$6.21^{gf} \pm 0.04$	$7.61^{i} \pm 0.05$
Uncha amirpur	$3.12^{ef} \pm 0.07$	$4.14^{e} \pm 0.08$	$6.02^{h} \pm 0.08$	$7.48^{g} \pm 0.05$
Nagla kashi	$3.17^{cde} \pm 0.04$	$4.32^{d} \pm 0.04$	$6.34^{de} \pm 0.06$	$8.08^{f} \pm 0.05$
Nidhauli	$3.25^{bc} \pm 0.07$	$4.28^{c} \pm 0.04$	$6.10^{gh} \pm 0.06$	$8.16^{e} \pm 0.07$

Values within a column showing the same letter are not significantly different at $p \leq 0.05$

Table.5 Correlation among the various plant characteristics and aerial deposition load in rice and wheat crop

Plant characteristics	**Correlation coefficient**	
	Aerial deposition on rice canopy	**Aerial deposition on wheat canopy**
Photosynthesis rate	-0.91	-0.95
Transpiration rate	-0.88	-0.90
LAI	-0.96	-0.96
Grain yield	-0.88	-0.94
Straw yield	-0.89	-0.92

Fig.1 Windrose map NTPC, Dadri

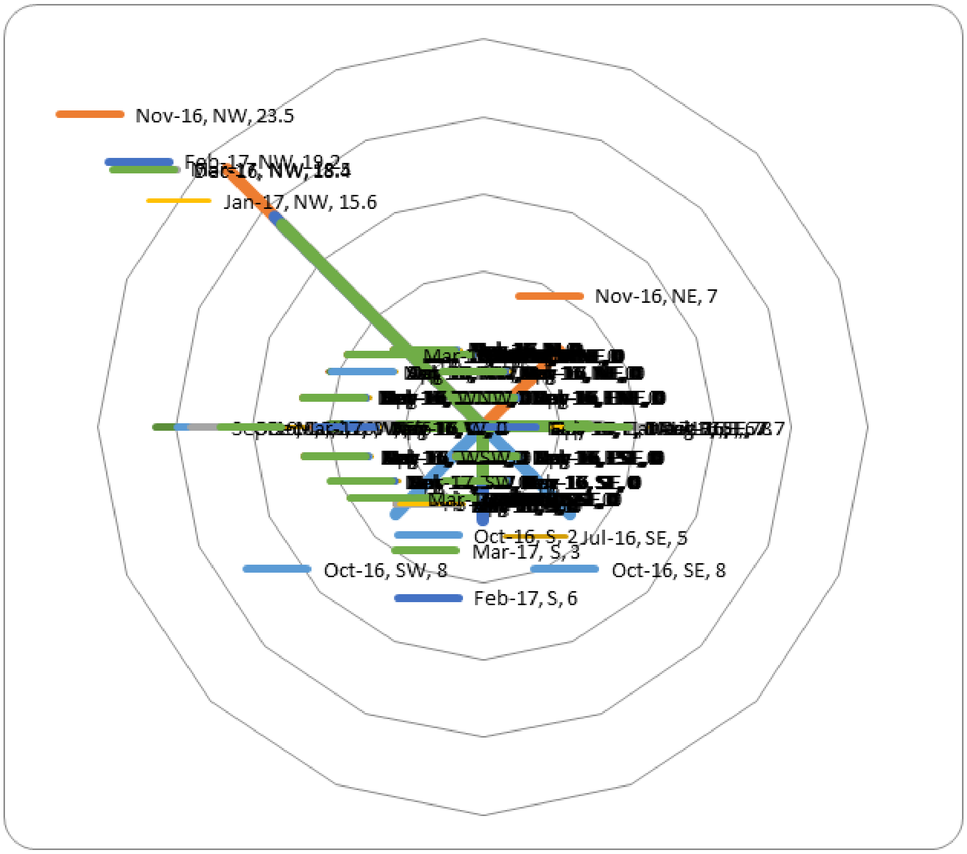


Fig.2 Map of Selected sites around NTPC Dadri

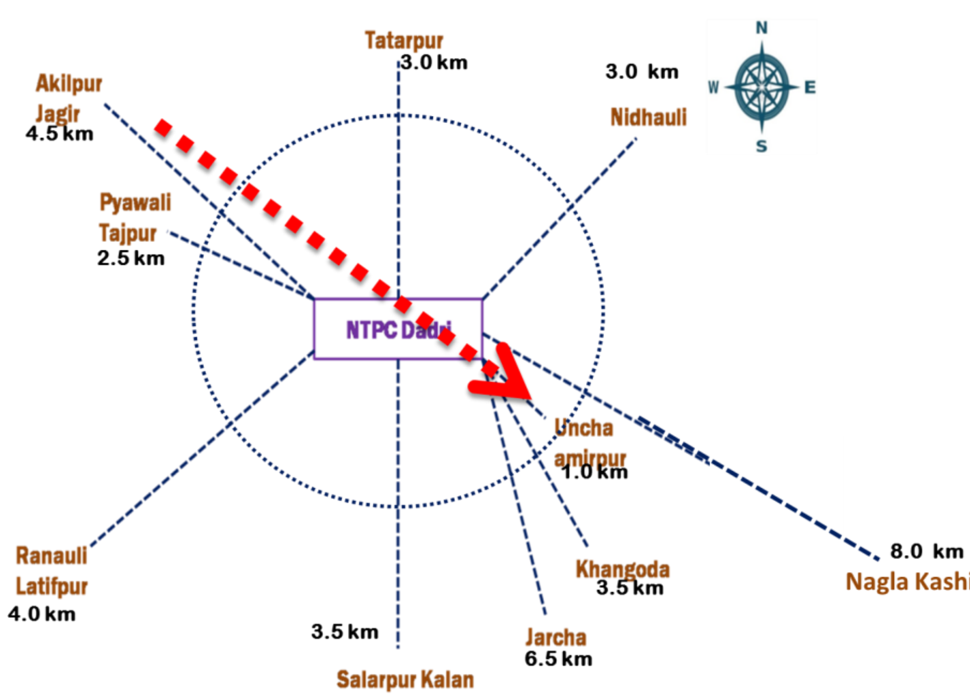


Fig.3 Aerial deposition rate (mg/cm^2) on crop canopy and photosynthesis rate (µmol/m^2/s) of rice crop at vegetative and flowering stages

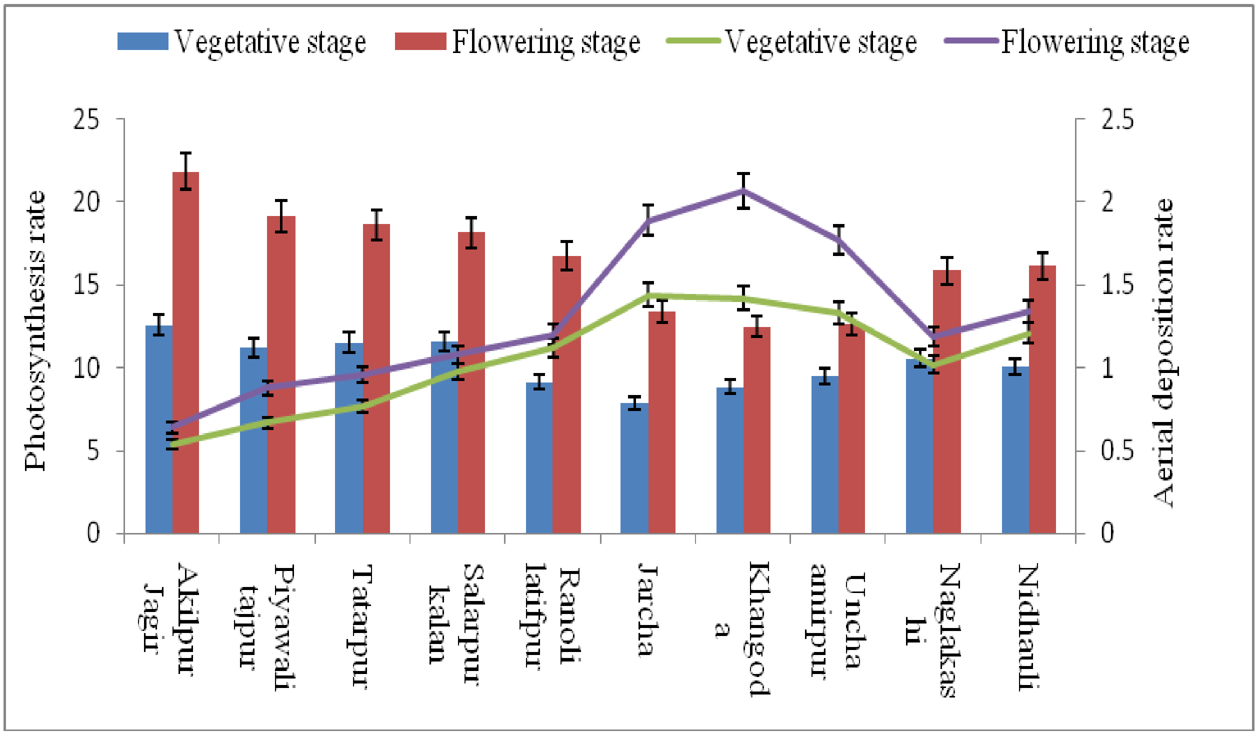


Fig.4 Aerial deposition rate (mg/cm^2) on crop canopy and photosynthesis rate (µmol/m^2/s) of the wheat crop at vegetative and flowering stages

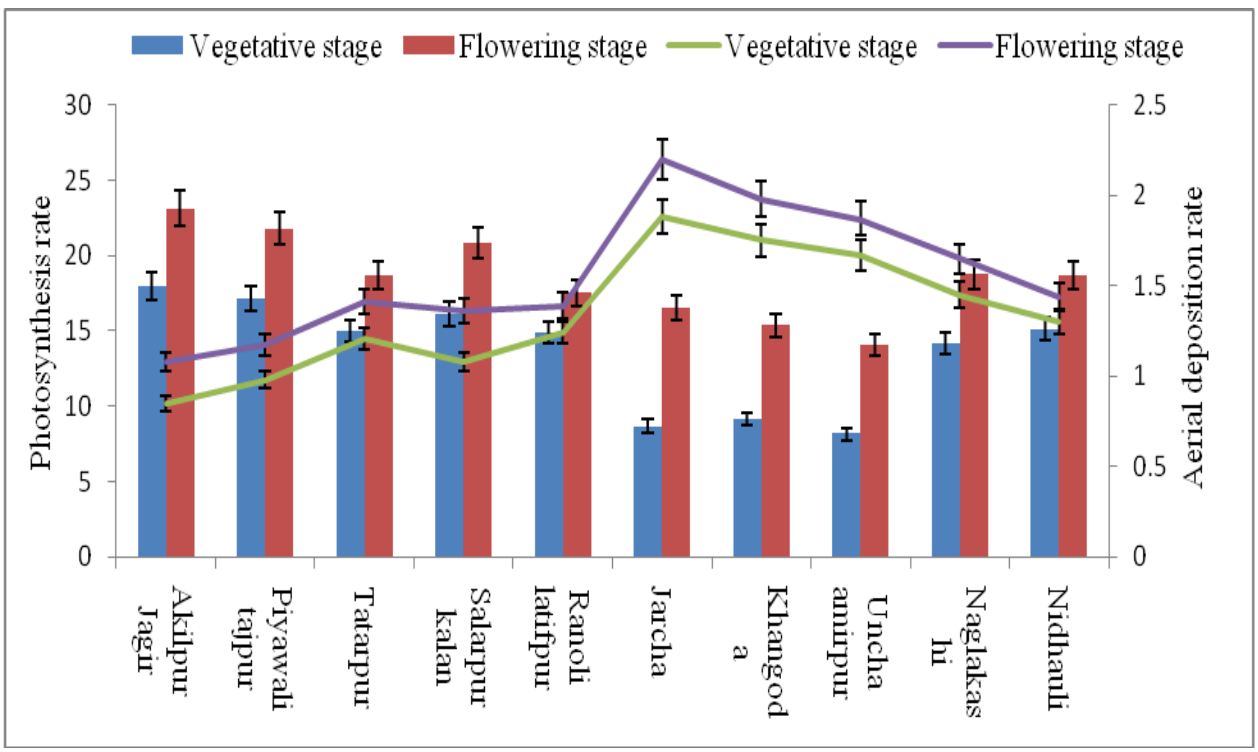


Fig.5 Aerial deposition rate (mg/cm^2) on crop canopy and Transpiration rate ($mmol\ m^{-2}\ s^{-1}$) of rice crop at vegetative andflowering stages

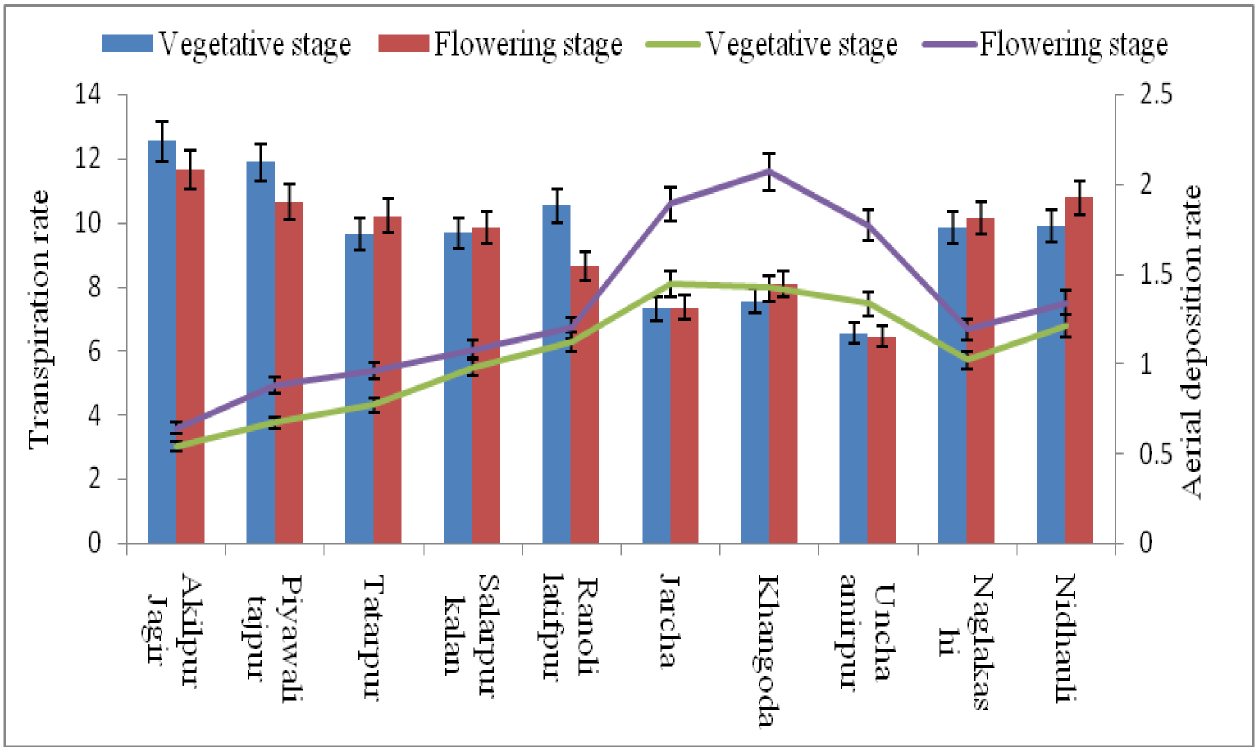


Fig.6 Aerial deposition rate (mg/cm^2) on crop canopy and Transpiration rate ($mmol\ m^{-2}\ s^{-1}$) of the wheat crop at vegetative andflowering stages

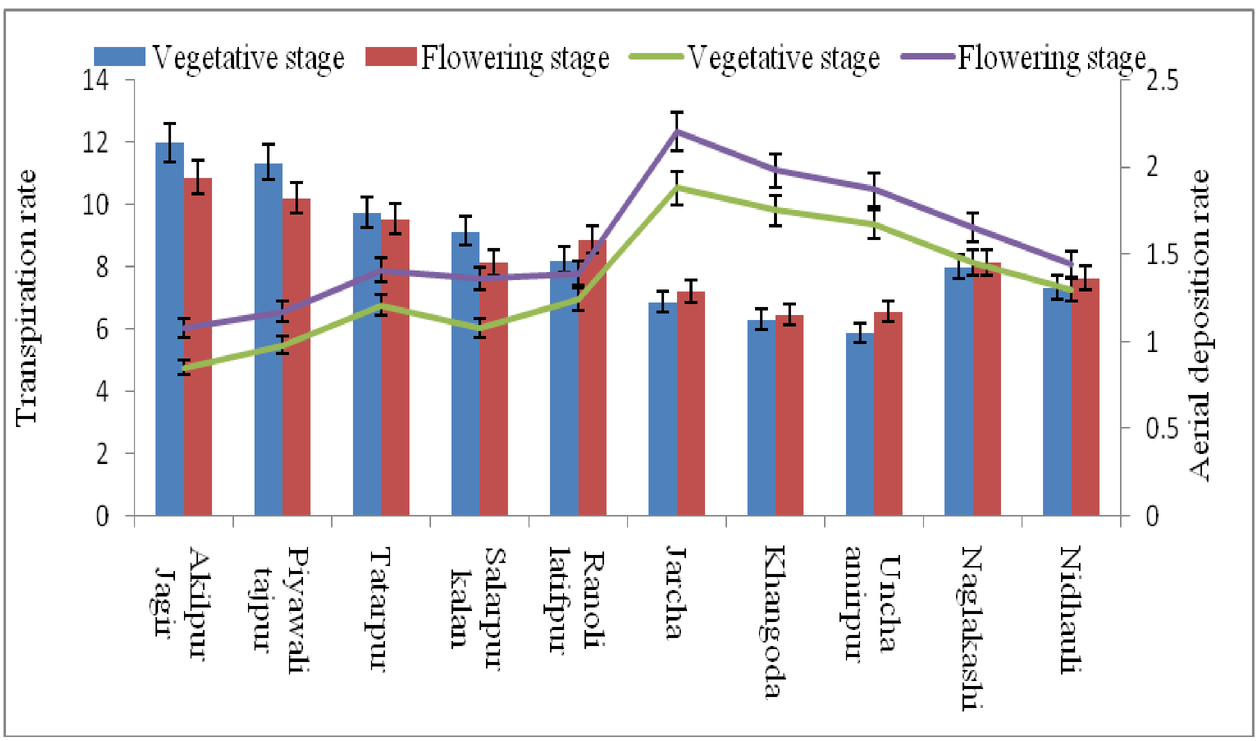


Fig.7 Aerial deposition rate (mg/cm^2) on crop canopy and Leaf area index (LAI) of rice crop at vegetative and flowering stages

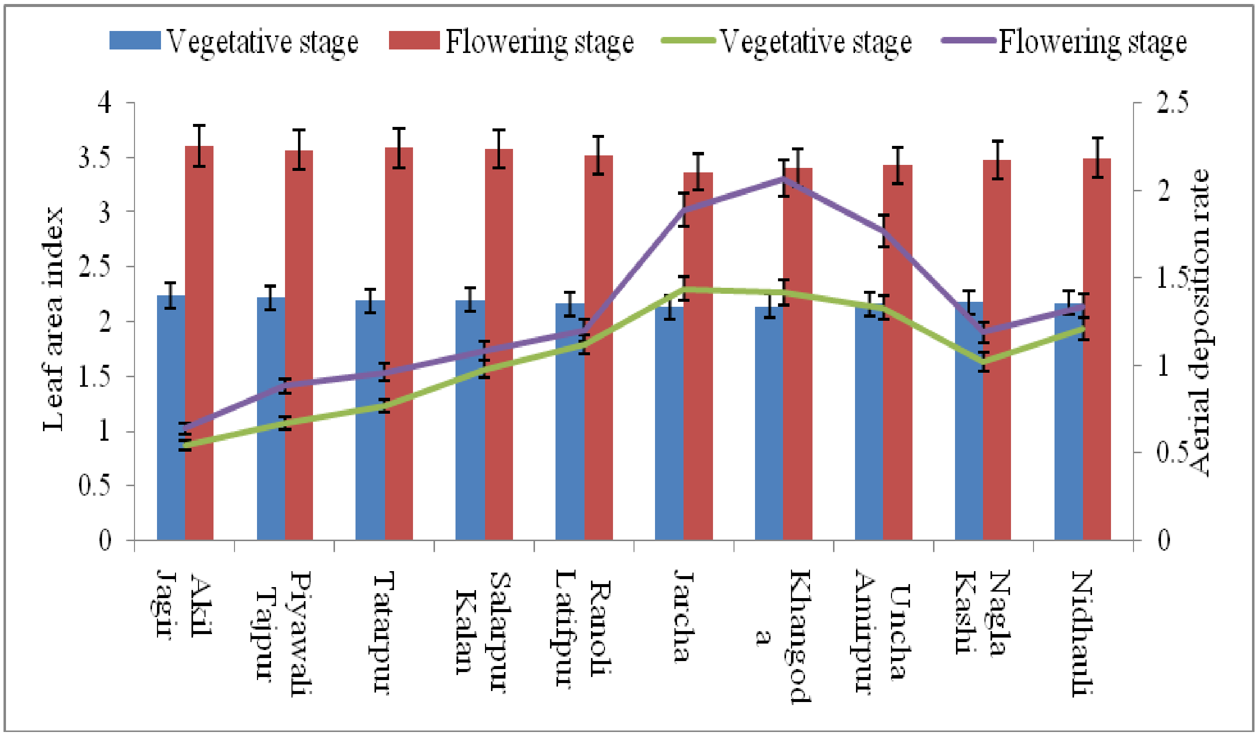


Fig.8 Aerial deposition rate (mg/cm^2) on crop canopy and Leaf area index (LAI) of the wheat crop at vegetative and flowering stages

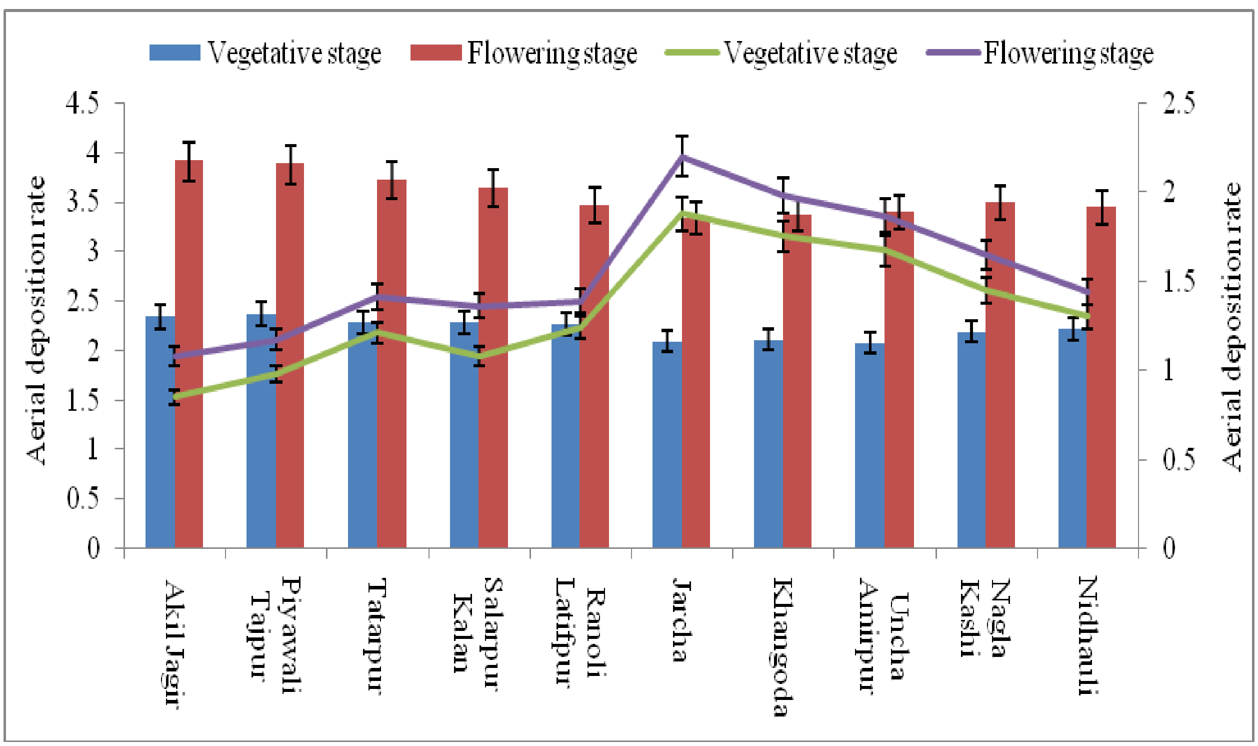
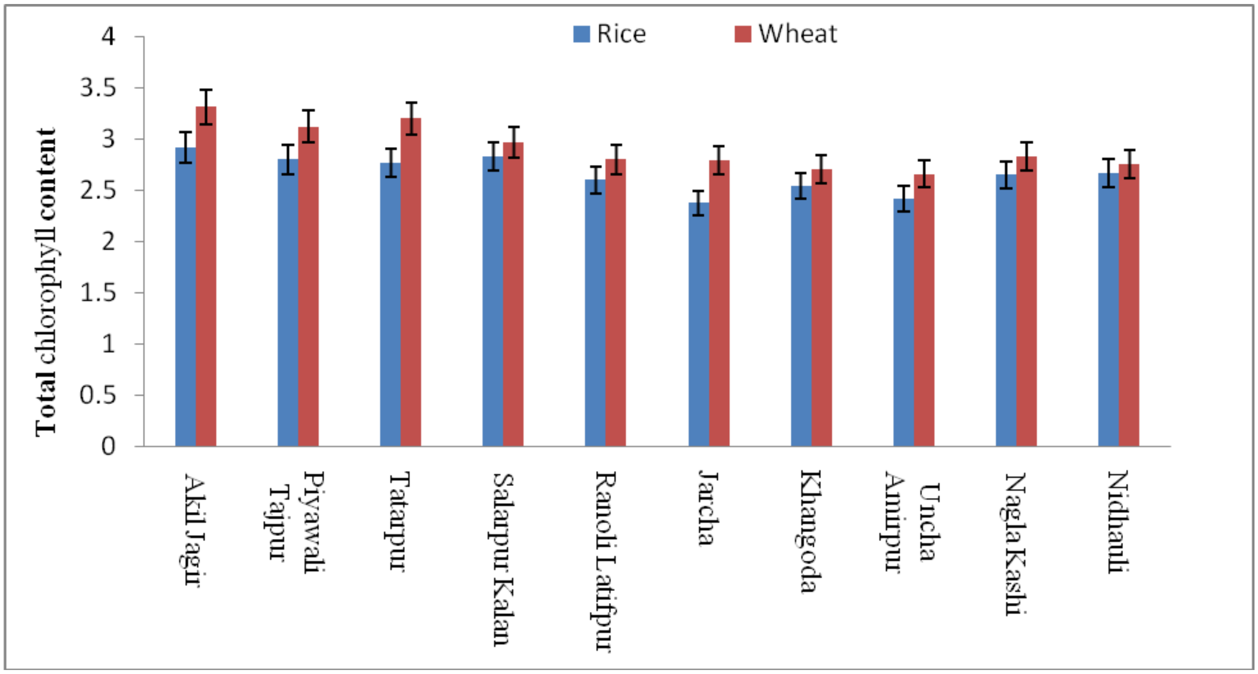


Fig.9 Total chlorophyll content (mg/g) of rice and wheat crop at flowering stages



Total chlorophyll content

Aerial deposition on crop canopy is directly affecting the total chlorophyll content. During the experiment, we found that in rice crop total chlorophyll content was maximum at Akilpur Jagir (2.92 mg/g) followed by Pyawali Tajpur (2.80 mg/g) and the minimum was at Jarcha (2.38mg/g) followed by Uncha Amirpur (2.42 mg/g) at flowering stage. Whereas in wheat crop total chlorophyll content was maximum at Akilpur Jagir (3.31 mg/g) followed by Pyawali Tajpur (3.12 mg/g) and the minimum was at Uncha Amirpur (2.66 mg/g) followed by Khangoda (2.71 mg/g) at flowering stage (Fig. 9).

Yield response to air pollution

When growth, physiological and biochemical parameters of crop plants are affected by some external activities, it ultimately affects the crop production. In our experiment, we found that air pollutants significantly affect the grain and straw yield of the crops. The study showed that grain yield of rice was reduced from 3.56% to 8.46% and in wheat from 2.84% to 9.52%. In rice maximum grain yield was at Akilpur Jagir (3.37 t/ha^{-1}) followed by Pyawali Tajpur (3.32 t/ha^{-1})and the minimum was at Jarcha (3.05 t/ha^{-1}) followed by Khangoda (3.08 t/ha^{-1}).Whereas in wheat maximum grain yield was at Akilpur Jagir (4.57 t/ha^{-1}) followed by Pyawali Tajpur (4.51 t/ha^{-1}) villages and the minimum was at Uncha Amirpur (4.14 t/ha^{-1}) followed by Khangoda (4.17 t/ha^{-1}). Chakrabarti *et al.*, (2014) reported that grain yield was reduced in rice 13.5% and 20.4%, while in wheat reduction were 21.9% and 19.1% in thefirst and second year of study, respectively due to air pollution. Agrawal *et al.*, (2005) reported thatSO_2, NO_2 and O_3 have detrimental effects magnitude on wheat, mustard, mung and palak plants. During summer, O_3seems to play a greater role in yield losses at a far away rural site, while O_3, SO_2 and NO_2 combinations caused yield losses at the most polluted site. Raja *et al.*, (2014) reported that a significant reduction of 12.3, 15.7 and 20.2

% in grain yield was observed over control site when fly ash was dusted at 0.5, 1.0 and 1.5 g m^{-2} day^{-1}, respectively.

In case of rice, straw yield reduction was from 5.61% to 11.08% and in wheat from 3.11% to 12.24%. In rice, the maximum straw yield was at Akilpur Jagir (6.77t/ha^{-1}) followed by Pyawali Tajpur (6.42t/ha^{-1}) villages and theminimum was at Uncha Amirpur (6.02 t/ha^{-1}) followed by Jharcha (6.07t/ha^{-1}). Whereas in wheat maximum straw yield was at Akilpur Jagir (8.67t/ha^{-1}) followed by Pyawali Tajpur (8.56t/ha^{-1}) villages and theminimum was at Uncha Amirpur (7.48 t/ha-1) followed by Khangoda (7.61 t/ha-1) (Table 3). Results showed that yield reduction in both the crops was recorded to be highest in leeward side and lowest on the windward side to TPP. Similar types of results were reported by earlier coworkers. Chakrabarti *et al.*, (2014) indicated that straw yield was reduced up to 17.6% and 24.5% rice and wheat crop respectively due to air pollution. Raja *et al.*, (2014) also showed that similar types of results, he reported that however fly ash deposition rate increased, straw yield was significantly reduced over control (Table 4).

Plant characteristics like photosynthesis rate,transpiration rate, LAI, grain yield and straw yield were found to be negatively correlated with atmospheric deposition on plant leaves. The correlation coefficient between aerial deposition and photosynthesis rate was –0.91 and –0.96 in rice and wheat crops respectively (Tables 5). Maximum negative correlation (–0.96) was observed between aerial deposition and LAI of both crops. The correlation coefficient between grain yield and aerial deposition of rice and wheat were -0.87 and -0.94 respectively. The correlation coefficient between straw yield and aerial deposition of rice and wheat were -0.94 and -0.95 respectively.

The study results that air pollutants from coal based TPP severely affect the growth and productivity at varying degree in rice and wheat crops. Air pollutants level was maximum at leeward side and minimum at the windward side to TPP. Ozone plays a significant role in summer whereas SO_2 and NO_2 in winter, but particulate matter as aerial deposition on crop canopy was the main culprit. An area of 2 to 6 km on the leeward side from the TPP is most sensitive to air pollution effects. So that diversified agriculture can be a sustainable option for the farmers to maintain their productivity and income.

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References

Agrawal, M., Singh, B., Rajput, M., Marshall, F., and Bell, J. N. B. 2003. Effect of air pollution on peri-urban agriculture: a case study. Environmental Pollution, 126(3), 323-329.

Alastuey, A., Querol, X., Chaves, A., Ruiz, C. R., Carratala, A., & Lopez-Soler, A. 1999. Bulk deposition in a rural area located around a large coal-fired power station, northeast Spain. Environmental pollution, 106(3), 359-367.

Anda, A., 1986. Effect of cement kiln dust on the radiation balance and yields of plants. Environmental Pollution Series A, Ecological and Biological, 40(3), 249-256.

Ashenden, T. W., and Williams, I. A. D. 1980. Growth reductions in

Loliummultiflorum Lam. and Phleumpratense L. as a result of SO_2 and NO_2 pollution. Environmental Pollution Series A, Ecological and Biological, 21(2), 131-139.

Ashmore, M.R., Marshall, F.M. 1999. Ozone impacts on agriculture: an issue of global concern. Advancesin Botanical Research 29, 32– 49.

Chakrabarti, B., Singh, R., Bhatia, A., Singh, S. D., and Singh, B. (2014).Impact of aerial deposition fromthermal power plant on growth and yield of rice (*Oryza sativa*) and wheat (*Triticum aestivum*). The Indian Journal of Agricultural Sciences, 84(5).

Darrall, N.M. 1989. The effect of air pollutants on physiological processes in plants. Plant Cell and Environment 12, 1–30.

Ja¨ ger, H.J., Unsworth, M.H., De Temmerman, L., and Mathy, P. (Eds.) 1993.Effects of air pollution on agricultural crops in Europe. Air Pollution Research Report 46.Commission of the European Communities, Brussels, Belgium.

Jackson, M.L. 1973. Soil Chemical Analysis, Prentice Hall of India Pvt. Ltd., New Delhi.

Jacob, M. B., and Hochheiser, S. 1958. Continuous sampling and ultra-microdetermination of nitrogendioxide in air. Analytical Chemistry, 30, 426.

Kumar, S., Prasad, S., Malav, M. K., and Gupta, N. 2016. Characterization and pretreatment of wheat straw using microwave assisted dilute acid to produce fermentable sugars for hydrogen production. Green Farming7 (1), 95-98.

Lehnherr, B., Grandjean, A., Machler, F., and Fuhrer, J. 1988. The regulation of photosynthesis in leaves of field grown spring wheat (*Triticum aestivum* L. cv. Albis) at different levels of ozone in ambient air. Plant Physiology 88, 1115–1119.

Marshall, F.M., and TeLintelo, D.T.H. 2001. Pollution Effects: Social and economic implications of urban and peri-urban agriculture in India. Urban Agriculture Magazine. NO 5 December 2001. Leusden, the Netherlands.

Mejstřík, V., 1980.The influence of low SO_2 concentrations on growth reduction of *Nicotiana tabacum* L. cv. Samsun and *Cucumis sativus* L. cv. Unikat. Environmental Pollution Series A, Ecological and Biological, 21(1), 73-76.

Pandey, J., Agrawal, M., Khanam, N., Narayan, D., and Rao, D. N. 1992.Air pollutant concentrations in Varanasi, India. Atmospheric Environment. Part B. Urban Atmosphere, 26(1), 91-98.

Pask, A. J. D., Pietragalla, J., Mullan, D. M., andReynolds, M. P. 2012. Physiological breeding II: a field guide to wheat phenotyping. Cimmyt.

Prajapati, S. K., 2012. Ecological effect of airborne particulate matter on plants. Environmental Skeptics and Critics, 1(1), 12.

Prusty, B. A. K., Mishra, P. C., and Azeez, P. A. 2005. Dust accumulation and leaf pigment content in vegetation near the national highway at Sambalpur, Orissa, India. Ecotoxicology and Environmental Safety, 60(2), 228-235.

Raja, R., Nayak, A. K., Rao, K. S., Puree, C., Shahid, M., Panda, B. B., and Lal, B. 2014.Effect of fly ash deposition on photosynthesis, growth, and yield of rice. Bulletin of environmental contamination and toxicology, 93(1), 106-112.

Ram, L. C., Srivastava, N. K., Jha, S. K., Sinha, A. K., Masto, R. E., and Selvi, V. A. 2007. Management of lignite fly ash for improving soil fertility and crop productivity. Environmental management, 40(3), 438-452.

Saha, D. C., and Padhy, P. K. 2011.Effects of stone crushing industry on *Shorearobusta* and *Madhuca indica* foliage in Lalpahari forest. Atmospheric Pollution Research, 2(4), 463-476.

Sharma, R., Pervez, Y., and Pervez, S. 2005. Seasonal evaluation and spatial variability of suspended particulate matter in the vicinity of a large coal-fired power station in India—a case study. Environmental Monitoring and Assessment, 102(1-3), 1-13.

Stone, R., 1992. NRC faults science behind ozone regs. Science, 255, 26.

Subbiah, B.V., and Asija, G.L. 1956. A rapid procedure for determination of available nitrogen in soil. Curr. Sci. 25, 259-260.

TeLintelo, D. J. H., Marshall, F., and Bhupal, D. 2002. Urban food: the role of urban and peri-urban agriculture in India: a case study of Delhi. Food, Nutrition and Agriculture, FAO Bulletin.

Walkley, A., and Black, I.A. 1934. An examination of aDegtjareff method for determining soil organic matter, and proposed modification of the chromic acid titration method. Soil Sci. 37, 29-38.

West, P. W., and Gaeke, G. C. 1956. Fixation of Sulphur Dioxide as Sufitomercurate III and Subsequent Colorimetric Determination. Analytical Chemistry, 28, 1816.

Xie, R., Seip, H. M., Wibetoe, G., Nori, S., and McLeod, C. W. 2006.Heavy coal combustion as the dominant source of particulate pollution in Taiyuan, China, corroborated by high concentrations of arsenic and selenium in PM 10. Science of the total environment, 370(2), 409-415.

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