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EFFECT OF AUTO EXHAUST EMISSION ON THE GROWTH, MORPHOLOGY AND BIOCHEMICAL CHARACTERISTICS OF MARIGOLD GROWN IN DIFFERENT SITES OF LUCKNOW

Nidhi Prakash* and Mohammad Yunus

Deptt. of Environmental Science, Babasaheb BhimraoAmbedkar University, Lucknow (U.P.)

**E-mail: nidhiprakash0107@gmail.com*

ABSTRACT: The present study was planned to evaluate the effect of auto-exhausts on a very common ornamental plant *i.e.* African marigold (*Tagetes erecta*) plants which also possess aromatic & medicinal properties and natural source of antioxidants. The plant is also recommended for growing with rose for its allelopathic nature. The area under marigold cultivation is increasing every year due to its increasing demand throughout the world. To assess the effect of auto-exhaust on marigold plants transfer experiment study was conducted. Three sites (Road stretches) within the municipal premises of Lucknow city were identified based on survey of sites and the available data on air pollution loads, which differ with each other very significantly in terms of the number of vehicles (source of pollution) plying there. A comparison of contents of photosynthetic pigments, protein, proline and cysteine among *Tagetes erecta* plants kept at three different sites very expilicitly indicates the bearing of auto exhaust effect on them. Marked alteration in bio-chemical characteristics of plant was observed in plants grown at highly polluted site as compared to plant grown at less polluted site.

Keywords: *Tagetes erecta, environmental stress, biochemical changes, morphological changes.*

Unsustainable industrial and urban development especially during the recent past has resulted deterioration in soil, water and air quality (Shafiq *et al.*, 34). Air Pollution has been identified as one of the most serious problem of a local/confined area to a scale of global. Air pollution caused huge losses to crop productivity and its quality by affecting plants growth and yield (Rajput and Agrawal, 28). Air pollutants may induce a wide range of visible symptoms, which has been used in biomonitoring and as an early warning to minimize the loss.

Many studies on the effects of air pollutants sourced by automobiles on morphology, physiology and biochemistry of plants have been carried out (Ahmed *et al.,* 2; Kozial and Whately, 22; Joshi and Swami, 17; Raina and Agarwal, 30; Rajput and Agrawal, 29; Salgere and Nath, 31; Treshow, 39; and Tripathi and Gautam, 38) in the different parts of the world.

Gaseous air pollutants and suspended particulates (SPM) cause serious damages on physiology of plants (Anda, 3; Ashenden and Williams, 5; Mejstrik, 27). Of all plant parts, leaf bears maximum brunt to air pollutants and other factors (Lalman and Singh, 24). Marigold (*Tagetes erecta*) is an important ornamental flowering and medicinal & aromatic plant of India. The area under marigold cultivation is increasing year to year due to its enhanced demand, particularly for its oil throughout the world. In recognition of the increasing cultivation of this plant for its medicinal and aromatic values, it was felt important to study the effect of auto exhaust emissions on response of bio-chemical characteristics of *Tagetes erecta*.

Fig. 1: Map of Lucknow city showing study sites.

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MATERIALS AND METHODS

Study area

The Lucknow city, in the central plain of the Indian subcontinent, is situated between $26^0$52'N latitude and $80^0$56'E longitude, 120 m above the sea level. It is the capital of Uttar Pradesh, one of the largest and highly populous states of India (Verma and Singh, 40). The city is spread over an area of 79 km^2 and has a population of more than 2 million. Lucknow has distinct tropical climate with a marked monsoonal effect. The temperature of the city ranges from a minimum of 5^0C in winter to a maximum of 47 ^{0}C in summer with the mean average relative humidity 60% and the average rainfall 1,406.8 mm.

An extensive survey of Lucknow city was made to select the sites (road stretches), which must differ conspicuously on numbers and type of vehicles plying there. Three different sites were identified for Transfer Experimental study, which are shown in (Fig 1).

BBA,University Campus (Site I–selected as control or unpolluted site). The university Campus is in an area of 250 acres, which is not open for thorough passes and has not developed the connecting roads. The expected pollution levels were negligible, much below the threshold values (almost a healthy environment).

SGPGIMS, Lucknow-Raebarelli Highway (Site II-heavy traffic load).

Transport Nagar Road, near Amausi industrial area, Lucknow-Kanpur Highway (Site III)

Air quality monitoring

Air quality monitoring was carried out twice a week during peak traffic hours using a portable high volume sampler for Suspended Particulate Matter and an attachment device (impingers) with sampler was used for monitoring gaseous pollutants. Using different absorbants: pararosaniline for SO_2, Sodium hydroxide arsenates for NO_2 and potassium iodide for O_3, the three major auto exhaust pollutants were measured. The methods of measurement of various pollutants and sampling period are given in Table 1.

Design of transfer experiment

Seedlings of certified variety of marigold were obtained from CIMAP, Lucknow. Two seedlings were planted in earthen pots having diameter 24 cm filled with garden soil and organic manure (3:1). After 15 days on the appearance of new leaves (a sign of plants establishment), plants were thinned by removing one and allowing one plant per pot and were transferred to selected sites for the transfer experimental study. At each site fifteen pots were kept.

Plant analysis

Growth parameters, viz., plant canopy, plant height, number of leaves per plant, leaf area were measured at 45 days, 90 days and 135 days. Pigment contents were assayed following the method of Arnon (4). Protein contents, cysteine, proline and malondialdehyde were determined following the method of Lowry *et al.* (25), Gaitonde (11), Bates *et al.* (6) and Heath and Packer (12), respectively. For each analysis three replicates were used on random basis.

RESULTS AND DISCUSSION

Ambient air quality monitoring showed significant spatial variations of the pollutants in suburban area of the city. Transport Nagar (site III) was highly charged with pollutants coming out of vehicles emission, followed by SGPGI (site II) crossing, while BBA university campus (site I) showed very low levels of pollution. It was observed that the concentrations of all the pollutants were maximum during day time between 10 to 11 am and 4 to 5 pm due to various urban activities at peak traffic hours.

The ambient concentration of these pollutants showed a direct relation with the traffic density at all the sites. As shown in Table 3 at site III, the vehicle plying were more as compare to site I, while

Table 1: Air Quality Monitoring (Parametres and Methodology).

Parameters	Time weighted average	Methods of measurement
Particulate Matter	8 hours twice a week	Gravimetric
Sulphur dioxide (SO_2)	8 hours twice a week	West and Gaeke (41)
Nitrogen dioxide(NO_2)	8 hours twice a week	Jacob and Hochhesier (15)
Ozone (O_3)	2 hours twice a week	Byers and Saltzman (7)

Table 2: Concentration of pollutants (µg m^3) at selected sites during September 2009 to Feb 2010.

Sites	Concentration of pollutants (µg m^3)				
	SO_2	NO_2	O_3	SPM	RSPM
Site I	8.92± 2.86	4.34 ± 0.32	12.21 ± 1.17	142.71± 11.10	56.92 ± 1.99
Site II	24.92± 3.50	54.88 ± 2.34	31.67 ± 2.82	328.33± 21.83	204.7± 3.50
Site III	32.53± 7.32	46.24 ± 3.17	29.86± 7.44	402.29± 27.37	267.58± 18.33

Values are mean ± SD of three replicates.

Table 3: Traffic density at the selected sites during 9 to 11 a.m. and 3 to 5 p.m. during study period.

Sites and days	Types of vehicles (Nos.)				
	Trucks + Tractors and Trollys	Buses (Petrol)	Four wheelers (petrol + diesel)	Two-wheelers	Three wheelers (Auto + Tempo) (CNG + Petrol)
Site I	01	1	52	87	02
Site II	126	76	437	1227	315
Site III **(after 45 days)**	426	81	589	1503	426
Site I	01	1	43	90	02
Site II	138	84	580	1615	278
Site III **(after 90 days)**	488	84	624	1308	451
Site I	01	1	46	76	04
Site II	143	89	527	1636	278
Site III (**after 135 days)**	509	91	616	1514	396

Values are mean (n=4)

site II had also high density of traffic but less than site III.

The concentration of SO_2 was highest at site III, which is situated near an industrial area having small-scale industries and some road intersections also, showed higher SO_2 concentration than other two sites. Transport agencies are also located in this area. NO_2 and O_3 concentration was found maximum at site II. SPM and RSPM level was alarmingly very high above threshold levels at site II and III as compared to site I. Changes in morphological characteristics, pigment concentrations, protein, proline, cysteine and MDA concentrations of marigold plants kept at different sites reflect varying levels of ambient air pollution experienced at different sites in suburban area around the city.

Plants leaves are the primary receptors for both gaseous and particulate pollutants of the atmosphere. Hence, they have to bear burnt of

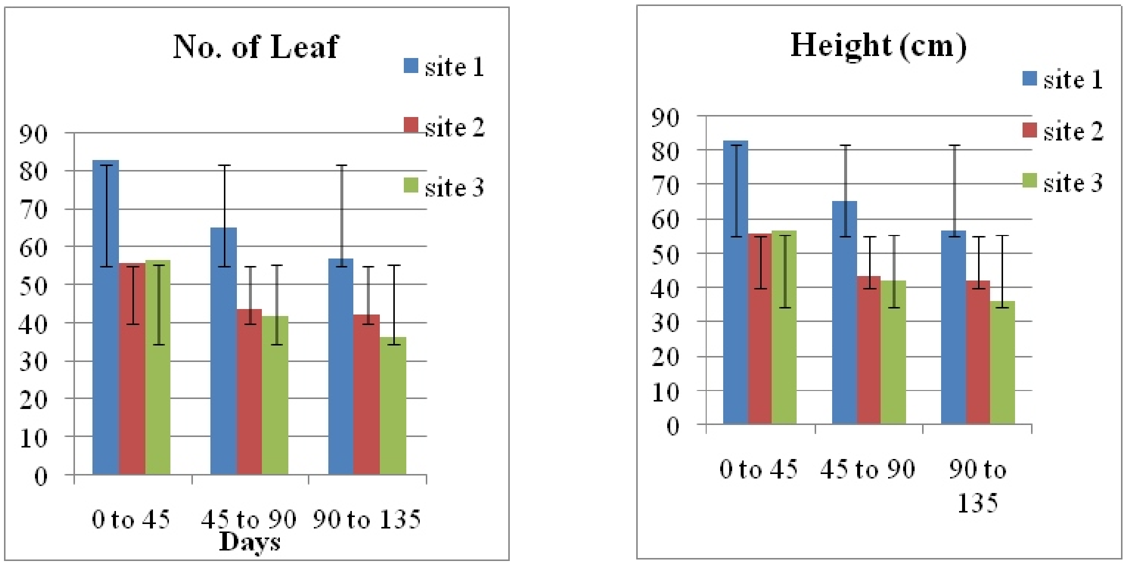

Fig. 2a : Number of leaves and plant height of *T. erecta* growing at different selected sites.

constant exposure to phytotoxic pollutants. Before these pollutants enter the leaf tissues, they interact with foliar surface and changes its configuration which seen as visible injuries and effect on growth (Verma and Singh, 40).

Plant height showed significant reductions at sites II and III, whereas number of leaves reduced significantly at site III as compared to site I (Fig. 2a). The plant experienced reduction of 8 to 11 % at site 3 and 5 to 8 % at site II as compared to site I. At both the sites II and III the plant showed a significant decline in the leaf number and leaf area. The leaf area and number of leaves showing reduction of 5% and 8 % and 17 % and 12% at site II and III, respectively (Fig.2a). This decline in the

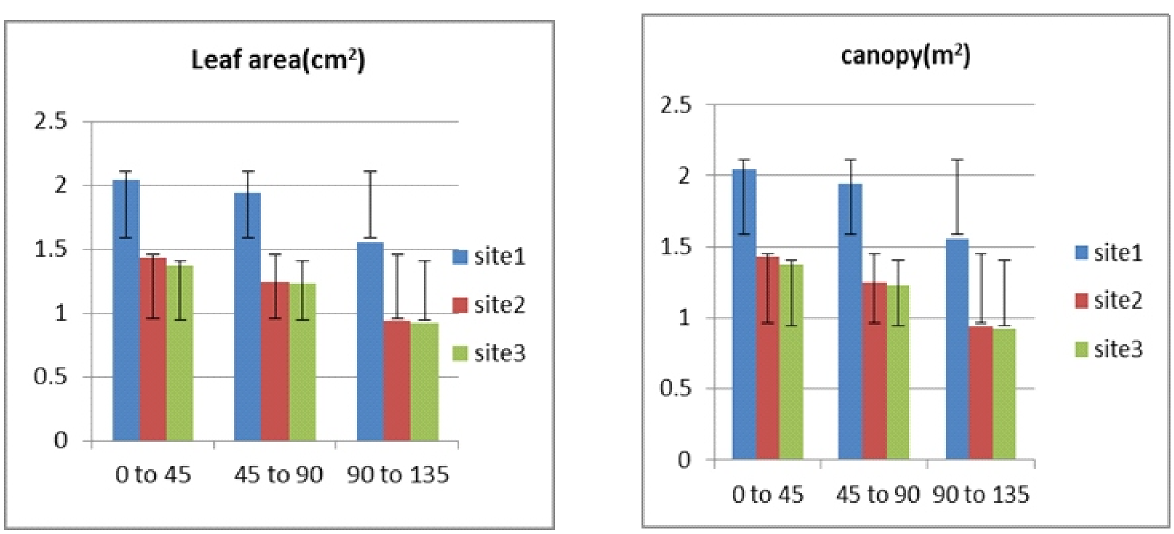

Fig. 2b : Leaf area and canopy of *T. erecta* growing at different selected sites.

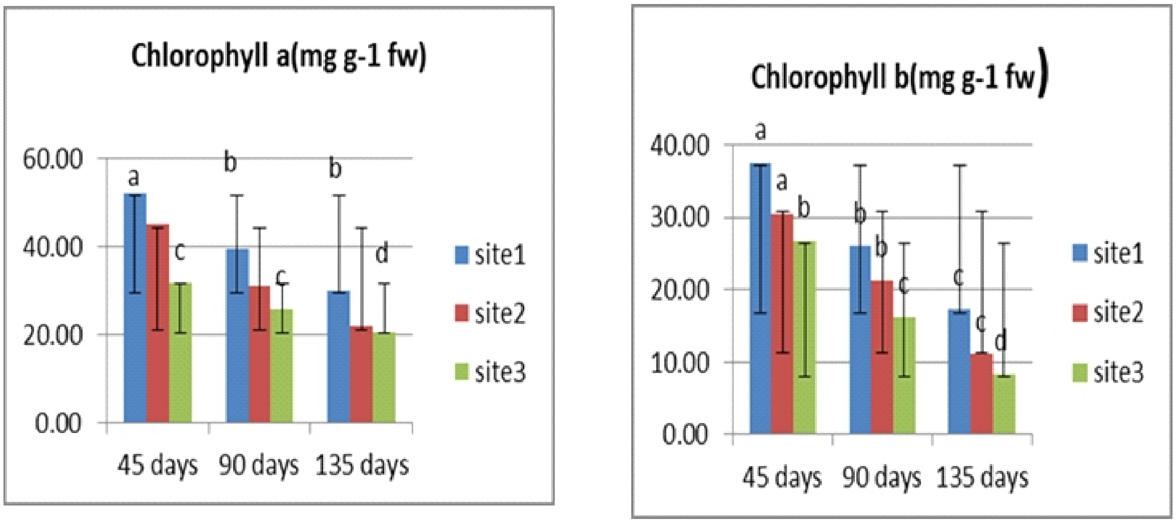

Fig. 3a : Chlorophyll a and b content of *T. erecta* at all the selected sites.

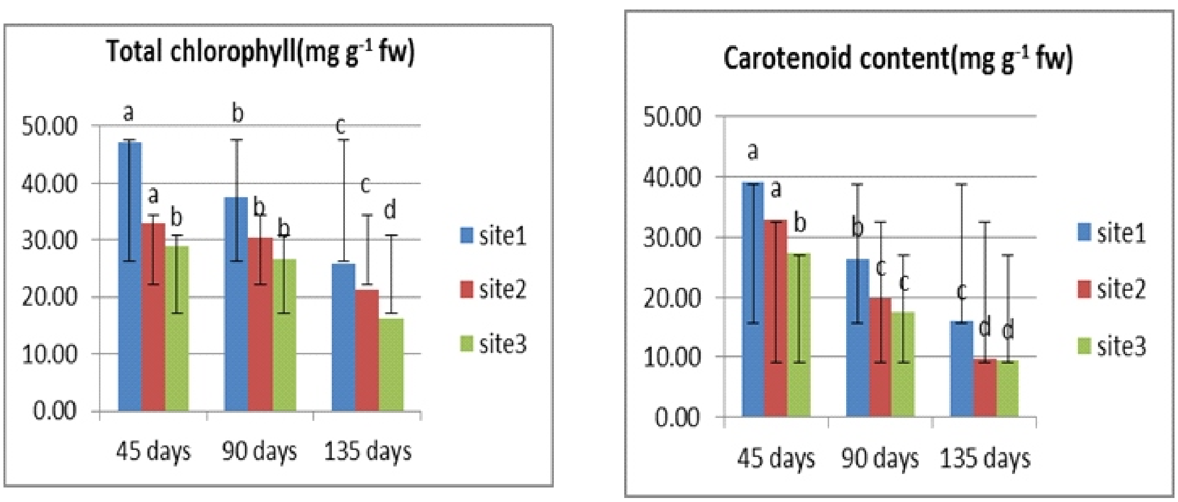

Fig. 3b : Total chlorophyll and carotenoid content of *T. erecta* at all the selected sites.

number of leaves may be due to the decrease in leaf production rate in response to the increasing pollution load. These results are in agreement with the findings of Ashenden and Williams (5) who have reported significant reductions in leaf numbers as result of SO_2 and NO_2 pollution. Salgare and Thorat (32) also observed a reduction in the leaf area of *Phaseolus vulgaris* after exposure to vehicular pollution.

Pollutants can cause leaf injury, decrease concentration of photosynthetic pigments, premature senescence and reduce growth and yield of the plants species. Tiwari *et al.* (37) recorded reduction of leaf area and petiole length under

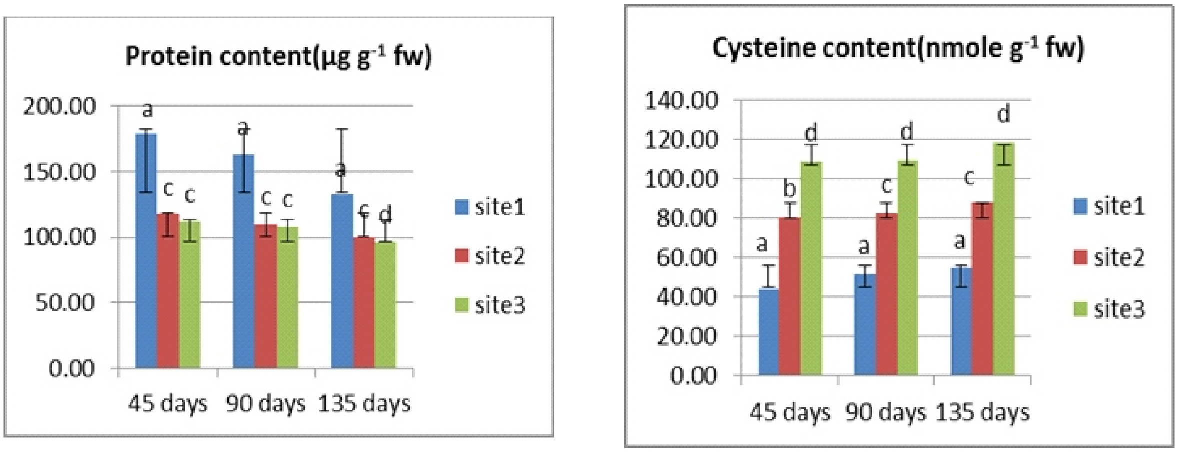

Fig. 3c : Protein and cystein content of *T. erecta* at all the selected sites.

pollution condition. Jahan and Iqbal (16) reported significant reduction in different leaf variables in the polluted environment in comparison with clean atmosphere. In their study on *Platanus cerrifolia* showed significant reduction in length and area and also number of leaflets and length of petiole.

Vehicular pollution stress leads to stomatal closure, which reduces CO_2 availability in leaves and inhibits carbon fixation. Net photosynthetic rate is a commonly used indicator of impact of increased air pollutants on tree growth (Woo *et al.*, 43). Plants that are constantly exposed to

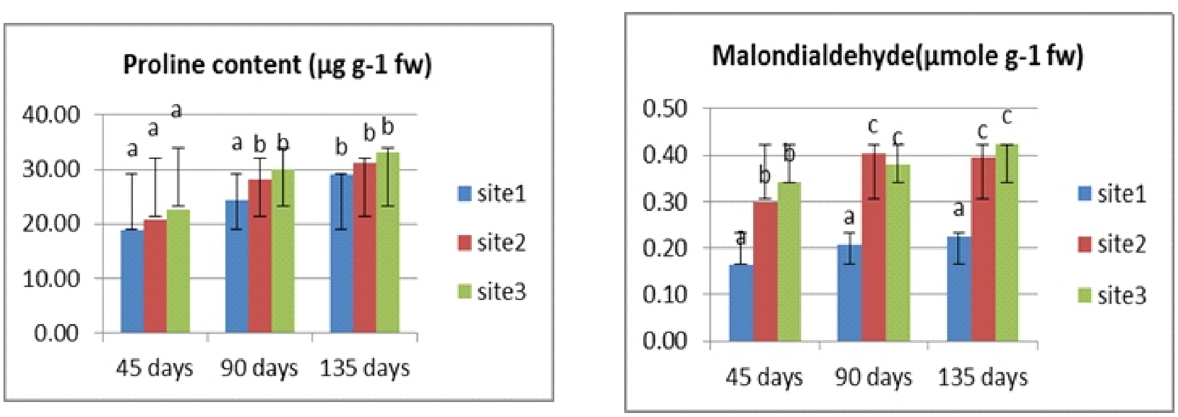

Fig. 3d : Proline and malondaldehyde content of *T. erecta* at all the selected sites.
*Different superscripts on bars showed significant (P < 0.05).

environmental pollutants absorb, accumulate and integrate these pollutants into their systems. It was reported that depending on sensitivity level, plants show visible changes which would include alteration in the biochemical processes or accumulation of certain metabolites (Agbaire and Esiefarienrhe, 1).

Oxides of nitrogen and sulphur, ozone as well as particulate matter, when absorbed by leaves may cause a reduction in the concentration of photosynthetic pigments *viz*., chlorophyll and carotenoids, which directly affect to the plant productivity (Joshi and Swami, 19).

The photosynthetic pigments are the most important to be damaged by vehicular pollution. Chlorophyll content could be a useful indicator for the evaluation of injury induced by pollutants (Knudson *et al*., 21). In present study it was noticed that the chlorophyll content of the plants was reduced at the polluted sites. The high value of chlorophyll 'a' and chlorophyll 'b' both were decreased at site III followed by site II as compared to site I, which is less polluted. It was noticed that chlorophyll a content decreased by 8 to 22% as compared to site III with site I (Fig. 3a) during different intervals of days. Chlorophyll 'b' also showed the same pattern of reduction, *i.e*. 9 to 13% (Fig. 3b).

Chlorophyll is said to be an index of productivity, hence any alteration in chlorophyll concentration may change the morphological, physiological and biochemical behaviour of the plant. Air pollution-induced degradation in photosynthetic pigments was also observed by a number of workers (Singh *et al.*, 35; Verma and Singh, 40).

The shading effects due to deposition of suspended particulate matter on the leaf surface might be responsible for this decrease in the concentration of chlorophyll in polluted area. It might clog the stomata thus interfering with the gaseous exchange, which leads to increase in leaf temperature which may consequently retard chlorophyll synthesis. Dusted or encrusted leaf surface is responsible for reduced photosynthesis and thereby causing reduction in chlorophyll content. High amount of gaseous SO_2 causes destruction of chlorophyll (Seyyednejad *et al*., 33). Reduction in chlorophyll content under air pollution has also been recorded by Tripathi and Gautam (38), Joshi and Swami (17) and Joshi *et al*.(18).

Carotenoids, which act as antioxidant and also protect chlorophyll from photooxidation, were also calculated and it was observed that carotenoid content, like other photosynthetic pigments, decreased with increasing pollution load in the surroundings. A decline of 8 to 14% was recorded (Fig. 3b). Losses in carotenoid pigments caused by various pollutants are in similar to Young *et al.* (44), Williams and Banerjee (42) and Verma and Singh (40).

With respect to site I a decline in the foliar protein content was also observed at the polluted sites. Maximum concentration of protein were recorded at site I during study period as compare to other two sites which showed a decrease of 38 to 62 % at site III and 32 to 55% at site II (Fig. 3c). Kumar and Dubey (23) have also concluded that pollutants coming out of auto-exhaust may cause inhibitory effect on protein synthesis.

In relation to the above parameters, a significant increase was noticed in foliar cysteine content of plant at the high polluted sites as compared to low polluted site (Fig.3c). Cysteine content was lowest at site with increase of 60 to 66% at site III and 30 to 43 % at site II. Tausz *et al.* (36) and Verma and Singh (40) have also observed the similar trend of increased cysteine content in plants exposed to air pollutants. Cysteine works as a buffering agent of SO_2 in the plant cell under the air pollution stress.

Proline is a universal osmolytic accumulated in response to several stress and may have a role in plant defense reactions (Khattab, 20). Obviously proline has main role in protection in different kinds of stress. Accumulation of proline in plants is a physiological response to osmotic stress (Seyyednejad *et al.,* 33). Significant increase in content of proline has been calculated at the high polluted sites as compared to low polluted sites. Proline content showed an increase of 6 to 11% at sites II and III as compare to site I (Fig. 3d).

Enhanced levels of Malondialdehyde was recorded at the polluted sites (site II and III) as compare to site I (Fig. 3d). Gaseous pollutants and particulate matter in environment chemically react with the double bonds of unsaturated fatty acids (Hippeli and Elstner, 13; Cross *et al.*,10) and thus possessing the potential to oxidize the unsaturated lipids. Canas *et al.* (9) reported positive correlation between traffic density and MDA content. Calatayud *et al.* (8) and Iglesisa *et al.* (14) also reported significant increase in lipid peroxidation in various plants under exposure to different air pollutants.

Conclusion

The results indicate that plants growing in polluted urban environments are likely to experience significant changes in physiological characteristics, pigment concentrations as well as potentially detrimental changes in leaf morphology characteristics and growth. Impacts on plant physiology, biochemistry, phenology and growth demonstrated that traffic-derived pollution is responsible for stress in urban environments, with important implications for plant performance and the health and sustainability of urban ecosystems. The study clearly showed that urban air pollution was unfavourably affecting the suburban ambient air. However, despite these changes, marigold was thriving well at the polluted environment. Therefore, this plant may be used as mitigator of pollutants of the automobile exhaust.

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