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Effect of road side dust pollution on the growth and total chlorophyll contents in *Vitis vinifera* L. (grape)

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The effect of dust in *Vitis vinifera* L. on its pigmentation and growth was studied in 2012. Measurements were taken for plants in the Campus University of Balochistan, Quetta. A significant reduction in plant length, cover, number of leaves and total chlorophyll contents for V. *vinifera* L. was observed. The maximum reduction of all **investigated variables such as plant length, cover, number of leaves and total chlorophyll contents on the fourth week of observation conform that long time accumulation of road side dust put long term savior effects on plant growth and its pigmentations. The results of this study also reveal that there is negative correlation between the amount of dust accumulation and plant growth parameters, as the amount of dust increased plant growth decreased, respectively.**

Key words: Dust, seedling growth, plant length, cover, number of leaves, and photosynthetic pigments.

INTRODUCTION

It is difficult to estimate the effects of air pollutants because the organisms are exposed to wide range of uncontrolled variables (parasites, weather conditions and complex mixture of pollutants). On the physiological and morphological point of view, the plants from polluted sites present important changes especially regarding their colors, shapes, leaf length, width, area and petiole length. However, despite these changes, plants survive well at the polluted environment (Leghari and Zaidi, 2013). Leaf is the most sensitive part to be affected by air pollutants. Therefore, the leaf at its various stages of development, serves as a good indicator to air pollutants. Air pollutants can directly affect plants via leaves or indirectly via soil acidification (Steubing et al., 1989). Pollutants when absorbed by the leaves cause a reduction in the concentration of photosynthetic pigment viz. chlorophyll which directly affects the plant productivity. Plants are the only living organisms, which have to suffer a lot from automobile exhaust pollution because they remain static at their habitat. Properties of both particulate matter and the vegetation are important in deciding their interactions, and consequently the effectiveness of particle removal from atmosphere. A number of recent studies observed that in urban atmospheres the concentrations of PM_{10}

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and PM $_{2.5}$ airborne aerosols show good agreement with traffic-related pollutants and other combustion processes (Prajapati and Tripathi, 2007); whereas, crustal material, re-suspended road dust and long-range transport events are mainly identified as sources of the coarse particles (Park and Kim, 2005; Vallius et al., 2005). Vehicular emissions and agricultural activities generate local dust concentrations close to the source which exceed environmental guideline values (Leys et al., 1998; Manins et al., 2001). Heavy metals released from automobiles are extremely toxic metal and reduces plant growth and morphological parameters. Therefore, the study conducted by Ahmad et al. (2012) is in agreement with this study stating that the cadmium had toxicity at 5 mgL^{-1} in case of root and shoot growth. Air pollution due to vehicular emission mostly arises from cars, buses, minibuses, wagons, rickshaws, motorcycles and trucks. These resources introduce varieties of pollutants (oxides of nitrogen and sulphur, hydrocarbon, ozone, particulate matters, hydrogen fluoride, peroxyacyl nitrates, etc.) into the environment which not only put adverse effect on the health of human beings, and animals, but seriously threating the trees and crops of such areas. Research studies revealed that plants growing in the urban areas are affected greatly by these pollutants (Uaboi-Egbenni et al., 2009).

Now it is necessary to identify some principles that may indicate these impacts, and the need for mitigation measures (Prajapati and Tripathi, 2008a, d). Air pollution in Quetta city (study area) is rising to an alarming state rapidly since the last few decades due to heavy automobile activities. Rapid increase in automobile activities and traffic congestion contributes most of air pollution problems, resulting in damage to the plants growth. Therefore, the present work was mainly designed to analyze the effects of air born-dust pollution, dom-nantly presented by automobile, industrial pollution and microclimate on physiology and morphology of *Vitis vinifera* L. (grape), because grape is one of the most widely grown fruit crops in the investigated area (Quetta city). They have a wide distribution, which indicates a high economically, ecologically plasticity in study area. Our goal in the present study was to evaluate the relationships between airborne dust deposition, physiological and growth parameters of *V. vinifera* L. (grape).

MATERIALS AND METHODS

Description of study area

Quetta is the provincial capital of Balochistan province. It is situated at an elevation of 1676 to 1900 m above sea level. The climate of the area is generally dry and cold. Maximum rainfall and snowfall occurs in January and February. Summer season is moderate, while June and July is the hottest month with maximum temperature of 30 and 20°C, respectively. January is the coldest month with mean maximum and minimum temperature of about 11 and -3°C, respectively (Anonymous, 1998). This variation in climate is the main ecological factor, due to which vegetation of southern zone differs from that of North. Due to variation in these factors, there is a variation in the penology of the vegetation from season to season.

The experiment was conducted in green house under the uniform natural environmental conditions at the Campus University of Balochistan, Quetta during March and April, 2012 in pots. Healthy and uniform size seeds of *V. vinifera* L. were collected from the University Campus. The seeds were sown in garden soil at 1 cm depth in large pots and watered regularly. After two weeks of their germination, uniform sized seedlings were transplanted in pots of 25 cm in diameter and 22 cm in depth containing the same garden soil in which they were germinated (Kabir et al., 2009). Road side dust was applied with ratio 1, 2, 3, 4 and 5 g, respectively on the aerial parts of each plant twice a week, except the control (0). The height of plant and cover were measured with a measuring tape. The numbers of leaves were also counted every week. The total experiments lasted six weeks (Mishra and Pandey, 2011).

Photosynthetic pigments analysis

Three grams of fresh leaves were put in 100% acetone (50 ml for each gram), homogenized (homogenizer B. Braun Melsungen, Germany) at 1000 rpm for 1 min. The homogenate was then filtered through double layered cheese cloths and centrifuged at 2500 rpm for 10 min. The extract was removed to a 10 ml graduated cylinder using a Pasteur pipette. An aliquot of the clear leaf extract (supernatant) was transferred with a pipette to a 1 cm path length cuvette and absorbance readings taken against a solvent blank in a ultra violet- visible (UV-VIS) spectrophotometer at 663, 645, 470, 435 and 415 nm wavelength to determine the concentrations of photosynthetic pigments like chlorophyll-a, chlorophyll-b and total chlorophyll content (TCh) using the formula given by Lichtenthaler (1987). The ratio of absorbance 663 to 645 nm are the parameter for maximum chlorophyll (a and b) absorbance in the experiment (Ronen and Galun, 1984).

Quantification of pigments (For 100% acetone)

Chl-a =12.7DX663 - 2.69DX645 x V/1000W (μg g^{-1} f.wt.)
Chl-b =22.9DX645 - 4.68DX663 x V/1000W (μg g^{-1} f.wt.)
TCh = Chlorophyll a + b (μg g^{-1}f.wt.)

Where, DX = Absorbance of the extract at the wavelength x nm, V = total volume of the chlorophyll solution (ml), and W = weight of the tissue extract (g).

Statistical analysis

The standard deviation values of the means were calculated for comparison of site categories. To determine the significance of the samples, paired t-test was performed (Steel and Torrie, 1980).

RESULTS

Effect of road side dust application on *V. vinifera* L. length, number of leaves, plant cover, total chlorophyll contents, over all comparison between plant variables and correlation between amount of dust applied and plant growth are shown in Tables 1 to 5 and Figure 1. In

Table 1. Effect of road side dust (gm) application on plant length during some weeks of growth.

Dust applied (gm)	Plant length (cm)			
	Weeks after dust application			
	1	2	3	4
Control	10.58	12.63	13.55	15.12
1	6.82	7.42	7.85	8.50
2	6.50	7.05	7.4	8.12
3	5.62	6.00	6.75	7.52
4	4.65	5.11	6.00	6.50
5	4.60	5.05	5.87	6.36
Average	5.6 (1.0)	6.1 (1.1)	6.8 (0.9)	7.2 (3.3)
Decrease percentage in Plant length with respect to the control	87.6	106.1	106.1	109.4
Confidence level (T-test)	**	***	***	***

Values in parenthesis indicates standard deviation, **highly significant $p < 0.01$, *** very highly significant $p < 0.001$.

Table 2. Effect of road side dust application on number of leaves.

Dust applied	Number of leaves			
	Weeks after dust application			
	1	2	3	4
Control	11.5	13.4	22.4	31.6
1	9	11	14	18
2	9	10	12	16
3	7	8	10	13
4	6	7	9	11
5	6	7	8	10
Average	7.4 (1.5)	8.6 (1.8)	10.6 (2.4)	13.6 (3.4)
Decrease percentage in No of plant leaves with respect to the control	55.4	55.8	111.3	132.4
Confidence level (T-test)	*	*	***	***

Values in parenthesis indicates standard deviation, *slightly significant $p < 0.05$, **highly significant $p < 0.01$, *** very highly significant $p < 0.001$.

general, *V. vinifera* L. showed a significant decrease in its growth, number of leaves, plant cover and total chlorophyll content due to road side dust treatment. Results also indicate that there was negative correlation between the application of dust concentration and growth rate during all the four weeks of investigation. As the concentration of dust application increased all the investigated parameters decreased, respectively. The study also reveales that reduction in plant length, plant cover, number of leaves and total chlorophyll contents varies from week to week and variation was also noted due to different concentration (1 to 5 g) of dust applied.

The maximum and minimum average plant length (7.2 and 5.6 cm) was noticed during 4th weeks and 1st week of dust application, respectively. Decrease percentage in plant length due to dust applied with respect to the control ranging from 87.6 to 109.4% and statistical analysis using T-test revealed that there was slightly to high variation in plant length between control and dust treatment (Table 1).

The numbers of leaves were significantly decreased in *V. vinifera* L. together with increasing dust accumulation in plant. The maximum and minimum average number of leaves (13.6 and 7.4) was noticed during 4th weeks and 1st week of dust application, respectively, on the other hand the plant with control site had 11.5 to 31.6 numbers of leaves. Decrease percentage in plant leaves due to dust applied with respect to the control ranging from 55.4 to 132.4% and statistical analysis using T-test indicated that there was slightly to high significant variation in number of leaves between control and dust treatment plants (Table 2). Table 3 shows that the average plant covers at dust application site were in the range of 93.7 to 134.0 cm^2, while plant at control site was 173.9 to

Table 3. Effect of road side dust application on plant cover (cm^2).

Dust applied	Plant cover			
	Weeks after dust application			
	1	2	3	4
Control	173.9	203.4	230.4	280.6
1	116.0	133.2	156.2	170.3
2	100.2	119.2	121.1	153.2
3	92.3	105.4	115.2	121.1
4	80.1	93.1	100.2	113.0
5	80.1	93.0	100.1	112.2
Average	93.7 (15.1)	108.8 (17.4)	118.6 (23.0)	134.0 (26.3)
Decrease percentage in plant cover with respect to the control	85.6	87.0	94.3	109.5
Confidence level (T-test)	**	**	**	***

Values in parenthesis indicates standard deviation, **highly significant $p< 0.01$, *** very highly significant $p < 0.001$.

Table 4. Effect of road side dust application on total chlorophyll contents.

Dust applied (gm)	Total chlorophyllcontents (µg g^{-1} f.wt.)			
	Weeks after dust application			
	1	2	3	4
Control	58.1	61.3	66.2	68.3
1	51.4	54.3	55.3	57.2
2	45.2	48.0	51.2	53.2
3	44.4	45.3	48.6	50.4
4	40.2	42.4	44.2	45.5
5	35.1	38.3	40.2	40.6
Average	43.3 (6.1)	45.6 (6.0)	47.9 (5.9)	49.4 (6.5)
Decrease percentage in total chlorophyll contents with respect to the control	34.4	36.8	38.2	38.4
Significance level (T-test)	n.s	n.s	n.s	n.s

Values in parenthesis indicates standard deviation, n.s: not-slightly significant $p < 0.05$.

Table 5. Correlation b/t dust applied and plant growth.

Plant variable	Correlation			
	Weeks after dust applied			
	1	2	3	4
Plant length (cm)	-0.94	-0.96	-0.98	-0.99
Number of leaves	-0.96	-0.95	-0.94	-0.90
Plant Cover (cm^2)	-0.96	-0.95	-0.94	-0.90
Total chlorophyll contents (µg g^{-1} f.wt.)	-0.98	-0.99	-0.99	-0.99

280.6 cm^2 which showed slightly to high significance. The decrease percentage in plant cover was noted to be 85.6 to 109.5%. Dust accumulation altered the chlorophyll and carotenoid contents in *V. vinifera* L. Greater decrease in total chlorophyll contents was clearly observed at 38.2 and 38.4% in 3rd and 4th weeks of dust application, respectively. Statistical analysis using T-test showed non-significant variation in total chlorophyll contents between control and dust treatment plants but there was variation within the dust treatment plants (Table 4). The plant growth (all the investigated variables) gradually decreased with the increased dust concentration. There was negative correlation between dust accumulation and plant growth as shown in Table 5. The minimum growth was noticed in the plants treated with 4 to 5 g dust without significant change between plants treated with 4

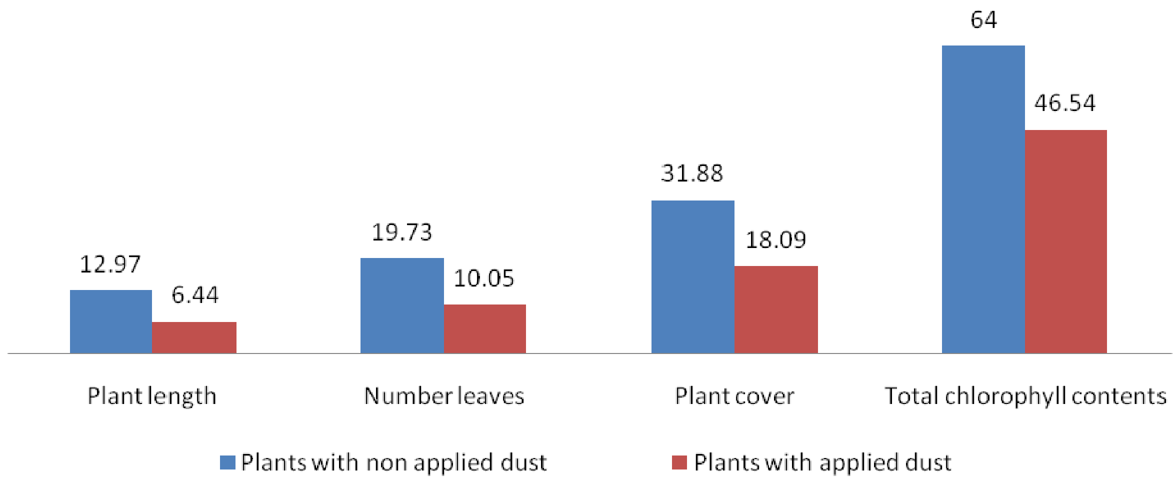

Figure 1. Over all comparison b/t different plant parameters of plants with non applied dust and plants with applied dust.

to 5 g during all the weeks. On the other hand, except total chlorophyll contents all the other investigated parameters showed significant over all difference between polluted and control site plants as indicated in Figure 1.

DISCUSSION

Road side dust had a significant effect on the growth of *V. vinifera* L. compared with non-dusted plant (*V. vinifera* L.). Reduction in plant height, cover, number of leaves and total chlorophyll contents of *V. vinifera* L. showed that the losses are generally attributed to the road side dust which contained mixture of toxic metals. The results obtained are in close conformity with those reported by Prajapati (2012) and Stratmann (1966), who dusted plants with dust ranging from 1 to 48 g/m^2 day^{-1} and concluded that dust falling on the soil caused a shift in pH to the alkaline side, which was unfavorable to oats but favorable to pasture grass.

Reduction of plant length might be due to the decrease in phytomass, net primary production and chlorophyll content in response to the road side dusts, similar to observation also noted by Prasad and Inamdar (1990) in Vignamungo (Black gram) and Armbrust (1986). A significant reduction in plant cover of *V. vinifera* L. suggests that it is more sensitive to road side dust. The observation noted by Shafiq and Iqbal (1987) is in agreement with these results; they found a reduction in the number of species around the heavily polluted cement industrial units in Karachi. Darley et al. (1966) demonstrated that dust deposited on bean leaves in the presence of free moisture interfered with the rate of carbon dioxide exchange, but no measurements of starch were made. The decreased in chlorophyll contents in the leaves of *V. vinifera* L. might be due to long time accumulation of dust on plant leaves that interrupt the sun light to reach the leaf. Prajapati and Tripathi (2008) observed reduction of pigment content in plant species due to dust accumulation. Similar results were also reported by Prasad and Inamdar (1990), they found that the dust kiln showed a reduction in chlorophyll content, protein, starch, yield and phytomass in ground nuts (*Arachis hypogaea* L.). A significant reduction in chlorophyll content, photosynthesis and growth in cotton due to particulates (dust) was also reported by Armbrust (1986). A significant reduction in leaf number for *V. vinifera* L. agrees with the findings of Laghari and Zaidi (2013); Anda (1986). Studies of biochemical changes and pollution effects on the plant metabolism, that is, reduction in chlorophyll and completely closed stomates (Ahmed and Qadir, 1975) revealed that these parameters are important in regulating the productivity and also the number of flowers and seeds produced.

Conclusion

On the basis of this study, it could be concluded that the phenological behavior of *V. vinifera* L. was found to be highly affected. It is clear that the road side dust pollution is an operative ecological factor causing deterioration in the quality of our environment and economic crops. It is suggested that the highly dust tolerant local plant species (*Pinus halepensis* (Miller.) and *Eucalyptus tereticornis* L.) should be planted around the road side. It is also suggested that complete analysis of road side dust containing toxic pollutants should be carried out in detail. The experimental analysis of the effect of dust on vegetation helps to recommend plants for use as screens or green belts in urban areas in order to mitigate dust and improve air quality (Yunus et al., 1985).

Conflict of interests

The author(s) have not declared any conflict of interests.

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