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Particulate matter effect on biometric and biochemical attributes of fruiting plants

[1]U. Younis; [1]*T.Z. Bokhari; [1]S.A. Malik; [1]M.H. Raza Shah; [2]M. Athar; [1]S. Niaz

[1]Department of Botany, Institute of Pure and Applied Biology, Bahauddin Zakariya University, Multan, Pakistan
[2]California Department of Food and Agriculture, 3288 Meadowview Road, Sacramento, CA 95832, USA

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ABSTRACT: Dust accumulation capacity of *Ficus carica* L. and *Psidium guajava* L. was investigated from eight different sites of Multan, Pakistan. Leaves of both plants were used for analyzing biometric (leaf area, fresh and dry weights) and biochemical attributes (chlorophyll contents, carotenoids and ascorbic acid). Maximum dust accumulation was occurred in the plants growing near road sites, while, minimum dust accumulation occurred in the plants of Bahauddin Zakariya University. Most of the biometric and biochemical attributes of *F. carica* showed significant response towards dust but it had not significant influence on some attributes of *P. guajava.* Biochemical traits of *P. guajava* appeared to be more prone than foliage ones. A positive correlation was found between dust accumulation and foliage attributes in *F. carica.* On the other hand, in *P. guajava* opposite was observed, however, the reverse was true for leaf biomass. Biochemical contents had shown an inconsistency as chlorophylls (a, b & total), carotenoid contents declined but ascorbic acid increased with an increase in dust accumulation in both species.

Keywords: *Biometric attributes, Biochemical attributes, Dust accumulation, Ficus carica, Psidium guajava*

INTRODUCTION

Universally and particularly in Urban areas many people suffered from variety of diseases due to dust pollution. Therefore, considerable attention is given to particulate matter pollution in the recent years (Jafary *et al.,* 2007; Cacciola *et al.,* 2002). Due to dryness of soil in the arid ecosystem the windblown dust is a common feature and plays a great role in increasing dust pollution in the environment (Younis *et al.*, 2013). Solid particles with diameter less than 500 µm are known as dust but particles which have size of 2.5-10 µm caused health problems for local public. Similarly high speed vehicles and agricultural activities also generate too much high dust pollution in air (Manins *et al.*, 2001; Van Jaarsveld, 2008).

Basically, outer surface of the plants like leaves play a role in absorbance of these dust particles (Samal and Santra, 2002). Thus in these areas the quality of air can be improved by planting more trees near road and farm sides (Beckett *et al.*, 2000; Freer-Smith *et al.*, 2005; Raupach *et al.*, 2001). But accumulation of dust by plants is dependent on their various characteristics like phyllotaxy and biometric attributes (pubescence of leaves), height and plants canopy. Because plants act as a sink in environment, so, they are useful in reducing dust concentration and other particulate matters of air. This accumulation is mainly depends on vegetation type (Younis *et al.*, 2013). Surface nature of the plants parts like twigs, bark and leaves offer an area for the settlement of these matters.

Dust pollution cause negative impact on plants as it reduced photosynthesis and cause leaf fall with tissue death (Farooq *et al.*, 2000; Shrivastava and Joshi, 2002). Dust affects the synthesis of chlorophyll and resulted in leaf chlorosis (Seyyednejad *et al.*, 2011). Similary morphology and anatomy of leaves is also altered by dust (Gostin, 2009; Sukumaran, 2012). At the same time many plants are able to survive in high dust load due to the synthesis of carotenoids and ascorbic acid which give non enzymatic resistance

*Corresponding Author Email: *tzb_5@hotmail.com*
Tel.: +91 061 4573463; Fax: +91 061 4573463

to plants to numerous abiotic stresses (Prajapati and Tripathi, 2008).

Multan is popular for dust storms and with the passage of time this problem is increasing day by day. Keeping in sight the above condition, the present work was aimed to estimate the disparity in dust gathering capacity of *Ficus carica* and *Psidium guajava* because species were present in a diversity of habitats in Multan. The foremost objective is to asses the role of leaves of these species in the reduction of dust pollution. In addition, foliage and biochemical traits were analyzed to suggest the probable mechanism of vegetation to combat stress induced by dust particles.

MATERIALS AND METHODS

Plant material and sampling

Two plant species (*Ficus carica* and *Psidium guajava*) were selected for study. Both species are small trees about 3-10 m tall. The phyllotaxy for the two species is opposite and alternate respectively. The selection of these two species was made because of their contrasting leaf characteristics. As the former species has broadly ovate foliage with long petiole, however, the later species has broad oblong elliptic leaves with short leaf stalk or petiole.

Cultivated inhabitants of two fruit varieties were chosen for sampling of plant tissues from 8 major areas of Multan city. The detail of these areas is summarized in Fig. 1.

Sampling protocols for dust and Leaves

Tress of *F. carica* and *P. guajava* plants were selected at each sampling location and 10 leaves were randomly marked on each plant at 1-3 m height. After removing leaves from branches they were packed in pre-weight glazed paper and brought to laboratory. Here the dust on the leaves was carefully cleaned by using fine brush on glazed paper and then papers were again weight. The dust accumulation was

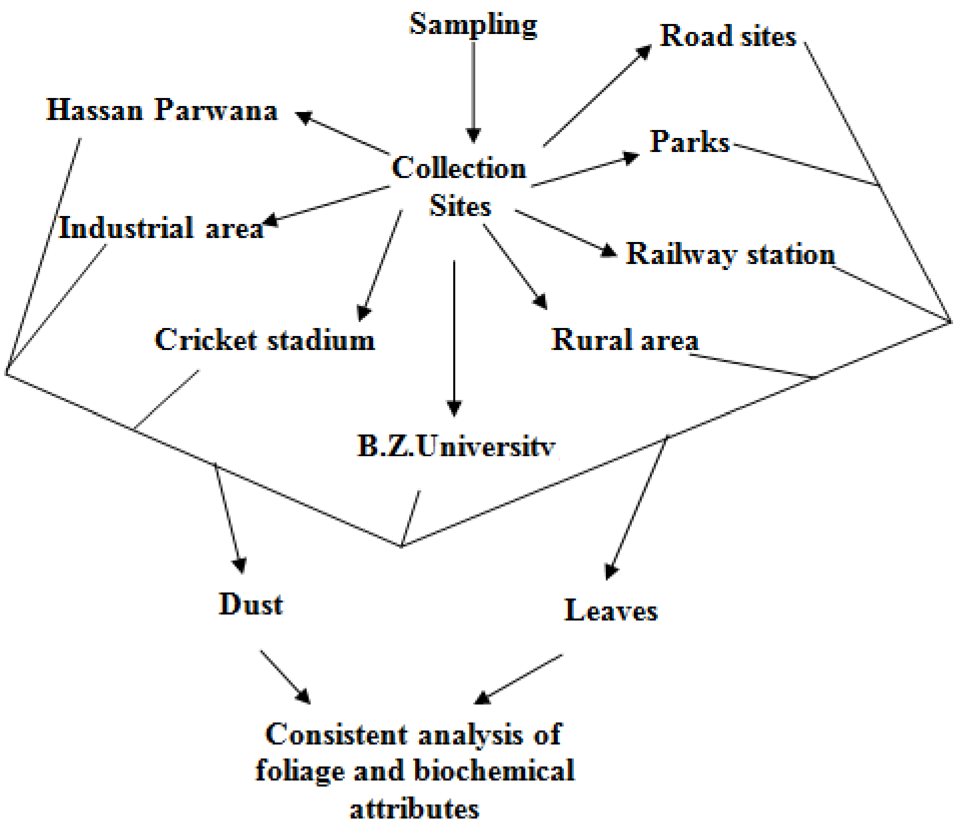


Fig. 1: Study sites with protocols in and around Multan.

calculated by using following formula (Prajapati and Tripathi, 2008).

W = (w2 – w1)/a

Where W is dust content (g/m), w1 is initial weight of glazed paper, w2 is final weight of glazed paper with dust, and "a" is total area of the leaf (m2).

Fresh weights of leaves were taken, than oven dried at 70° C for 72 h for dry weight measurements.

Chlorophyll determination

0.2 g fresh leave samples were extracted overnight with 80% acetone (4 ml) then grinded and homogenized well in pestle and mortar. The homogenized mixture was filtered and volume of the filtrate was raised up-to 25 ml with 80% acetone. The absorbance of the chlorophyll filtrate was determined at 663, 645 and 480 by spectrophotometer (Optima 2100 DV Perkin-Elmer). The chlorophylls (a, b and total) contents were calculated by the following formulae:

Chlorophyll "a" (mg/g F. W) = [12.7 (OD 663) -2.69 (OD 645)] x V/1000 x W

Chlorophyll "b" (mg/g F. W) = [22.9 (OD 645) -4.68 (OD 663)] x V/1000 x W

"Total" chlorophyll (mg/g F. W) = [20.2 (OD 645) +8.02 (OD 663)] x V/1000 x W

V = Filtrate volume (mL)

W = Leaf weight (g)

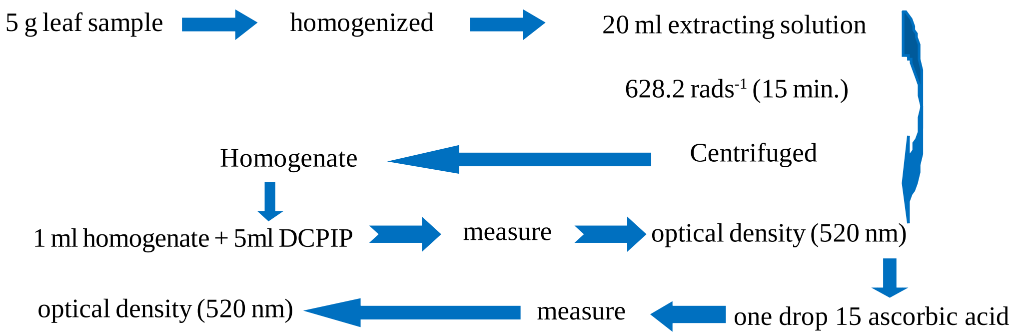
OD =optical density

Ascorbic Acid

For determination of ascorbic acid 5 g of fresh leaves were grinded and homogenized in 20 ml extracting solution (5 g oxalic acid + 0.75 g Na salt of EDTA 100 ml distilled water. After centrifugation at 682.2 rads^{-1} for 15 minutes, the 1 ml of homogenate was mixed carefully with 5 ml DCPIP (Dichlorophenol indophenol). Color of homogenate changed into pink, its absorbance was noted at 520 nm then one drop of 1% ascorbic acid was added to make solution colorless. The absorbance of colorless solution was also noted at same wavelength. A standard curve was draw by using ascorbic acid solution of different dilution (0.01–0.07 g/L). The ascorbic acid was determined by following Keller and Schwager, (1977).

Ascorbic acid (mg/g F.W) = [((Eo-Es-Et)V/100 x W) x 100]

For determination of ascorbic acid following procedure is used



where, E_o=OD of blank, E_s=OD of plant sample and E_t = OD of sample + ascorbic acid, V = extract volume; and W = leaf sample weight (g).

RESULTS AND DISCUSSION

Fig. 2 A represented the dust accumulation or dust load on leaves of *Ficus carica* and *Psidium guajava* under study. It is evident from the Figure that *F. carica* and *P. guajava* showed higher dust deposition on leaves at road sides followed by parks, railway station, Pak Arab Fertilizer - Industrial Estate, cultivated wheat field, cricket stadium area and lowest at Bahauddin Zakariya University. It is also cleared from the mentioned figure that *F. carica* leaves had more dust accumulation than *P. guajava* leaves.

Higher dust accumulation had affected foliage attributes of *F. carica* and *P. guajava* and leaf area of *F. carica* increased (146.48 cm^2) and *P. guajava* decreased (37.81 cm^2) with increasing dust accumulation (Fig. 2 B). Whereas significant increased of fresh and dry weights of leaves of *F. carica* and *P. guajava* was observed with increasing dust accumulation. The maximum leaf fresh and dry

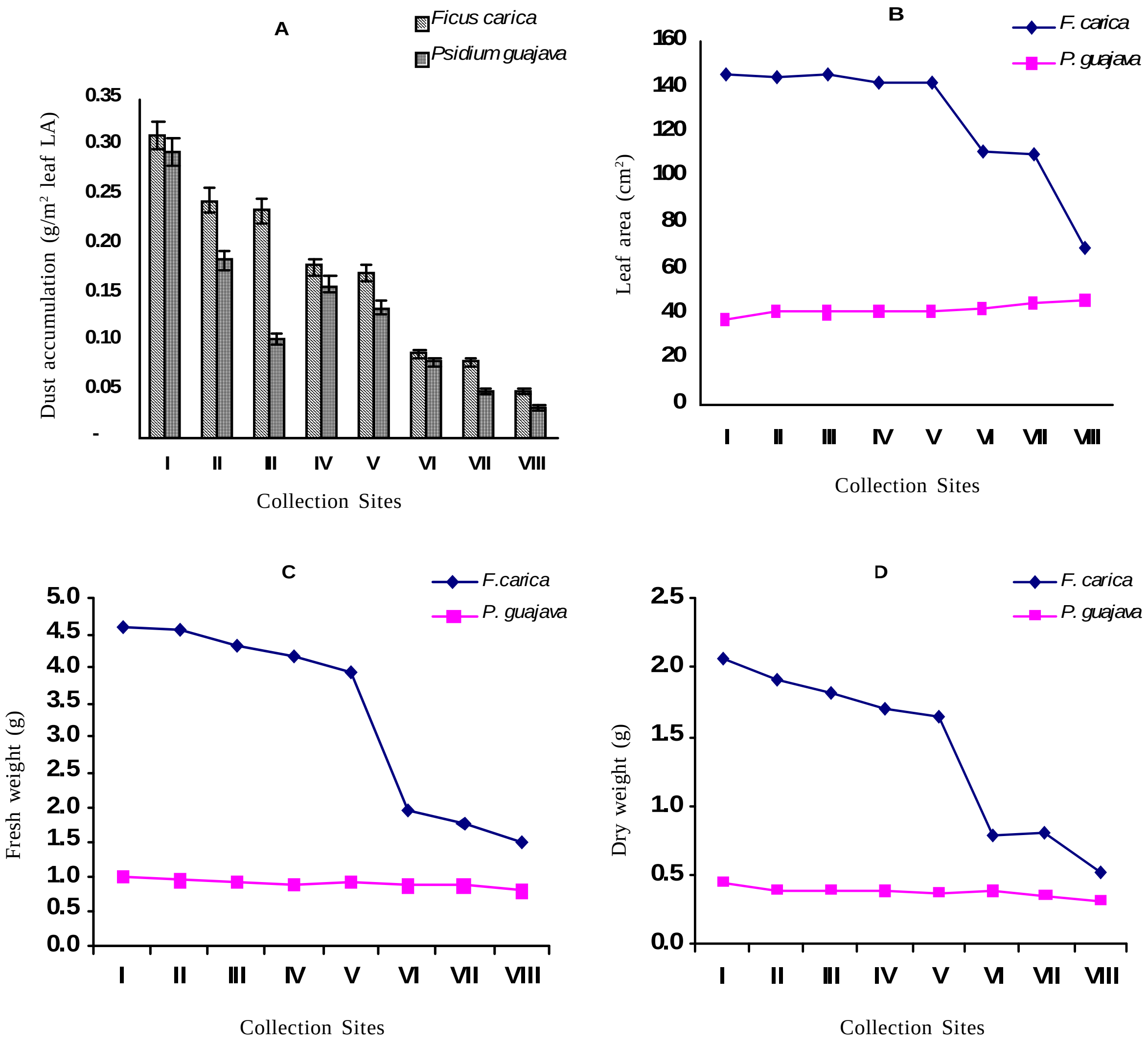


Fig. 2: A. Dust accumulation, B. Leaf area, C. Leaf fresh weight, D. Leaf dry weight of *F. carica* and *P. guajava* collected from different sites of Multan, Pakistan (*Values are means of ten replicates)*

weights were observed in the plants growing at road sides with more dust accumulation and minimum were observed in the plants growing in Bahauddin Zakariya University with minimum dust accumulation. (Fig. 2 C and D). The *F. carica* and *P. guajava* had the maximum leaf fresh weight (4.59 g & 1.01 g) at more dust accumulation site. Although, a gradual reduction of leaf fresh weight (1.49 g and 0.79 g) was observed in the plants of *F. carica* and *P. guajava* growing at lowest dust accumulation site (Fig. 2 C). The leaf dry weight also exhibited a similar trend as shown by fresh weight and a noticeable inhibition in dry weight was observed with increasing dust accumulation where leaves of both plants produced 2.06 and 0.45 g of dry weight as compared with 0.52 and 0.32 g of leaves of the plants growing at minimum dust accumulation site (Fig. 2 D).

The carotenoids and chlorophyll contents were comparatively higher in the plants growing at lowest dust accumulation site but dust load induced a

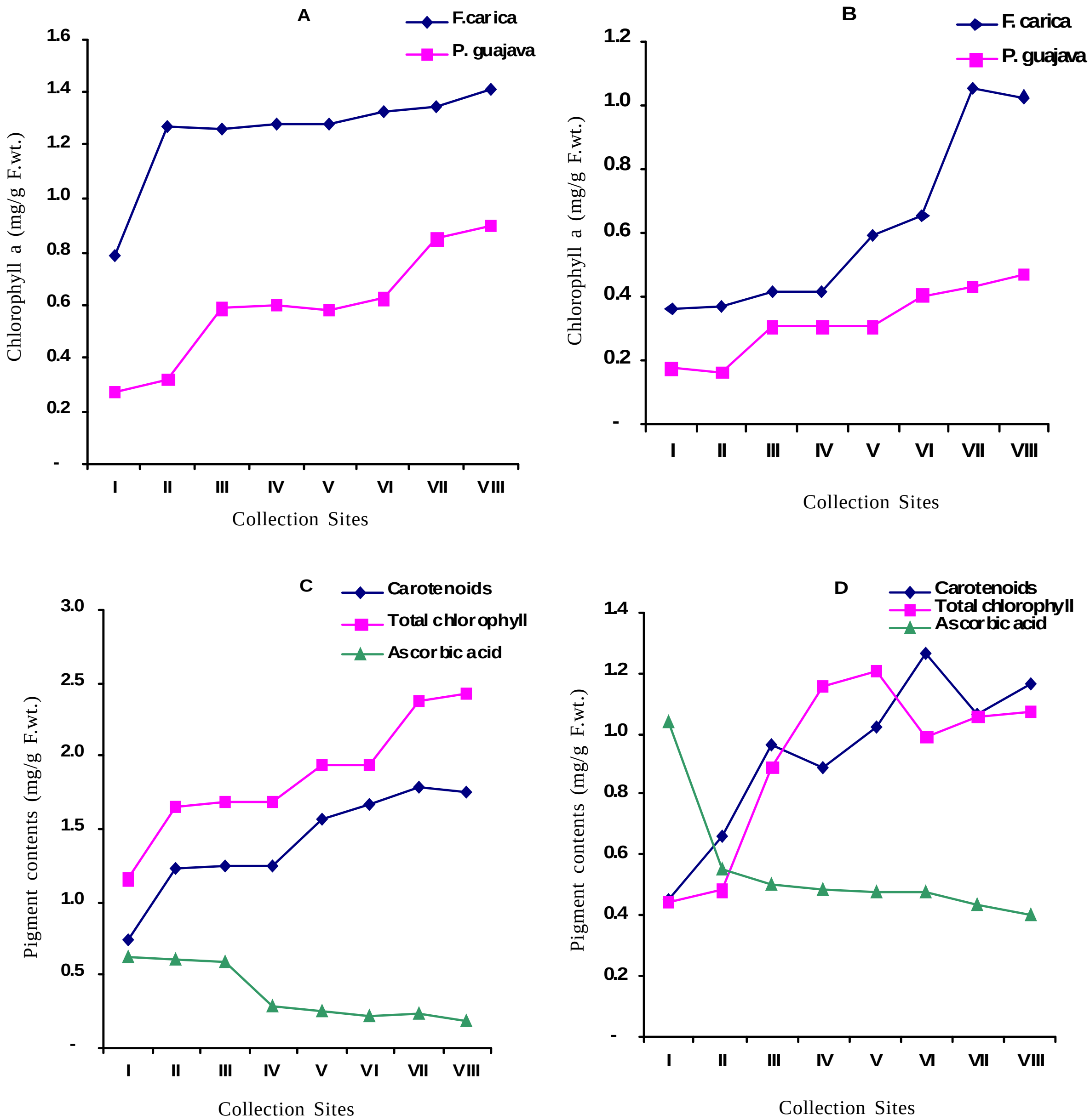


Fig. 3: A and B. Chlorophyll (a & b) contents of *F. carica* and *P. guajava*, C & D Ascorbic acid, Carotenoids and Total chlorophyll contents of *F. carica* and *P. guajava* collected from different sites of Multan, Pakistan *(Values are means of five replicates)*

profound decline in chlorophyll *a*, *b* and carotenoids contents (Fig. 3 A, B, C and D).

The pigments declined progressively with increasing dust accumulation. The amount of chlorophyll *a* in *F. carica* and *P. guajava* growing at lowest dust accumulation site was 1.40 and 0.89 mg/g (Fig. 3 A), whereas amount of chlorophyll b was 1.02 & 0.47 mg/g and amount of carotenoids was

Table 1: Correlation of dust accumulation with biometric and biochemical attributes of *F. carica* and *P. guajava* collected from different sites of Multan, Pakistan

Foliage and biochemical attributes	Plant species *Ficus carica*	Plant species *Psidium guajava*
Leaf Area	0.85	-0.91
Leaf Fresh weight	0.934	0.912
Leaf Dry weight	0.959	0.906
Chlorophyll a	-0.786	-0.916
Chlorophyll b	-0.878	-0.908
Total chlorophyll	-0.935	-0.703
Carotenoids	-0.945	-0.919
Ascorbic acid	0.91	0.886

1.75 and 1.63 mg/g. However, at higher dust accumulation site, chlorophyll *a* of *F. carica* and *P. guajava* decreased to 0.79 & 0.27 mg/g and chlorophyll b was decreased to 0.37 and 0.17 mg/g (Fig. 3 B, C and D). A dramatic decline in carotenoids content was also observed in both plants and 0.74 mg/g and 0.45 mg/g of this pigment was recorded at higher dust accumulation site (Fig. 3 C and D).

The variations in leaf pigment content of *F. carica* and *P. guajava* under study are presented in Fig. 3 (C and D). It is obvious from the results that more total chlorophyll content were observed in the plants growing at lowest dust accumulation site. From the study it is conclude that ascorbic acid and chlorophyll and inversely proportional to one another. The ascorbic acid concentration in both plant species was highest at more dust accumulation site (Road sides).

The study demonstrates the changes in foliage attributes and pigment contents in *F. carica* and *P. guajava* exposed to atmospheric dust fall. Chlorophyll + carotenoid contents reduced and ascorbic acid values increased with increasing dust accumulation on leaves. The correlation values of dust accumulation with foliage attributes and pigment contents in *F. carica* and *P. guajava* is presented in Table 1.

Table 1 clearly shows that there is highly negative correlation between dust freight and chlorophyll contents (a, b, total) and carotenoids contents but too much high + ive correlation was observed between dust amount and ascorbic acid content and leaf biomass.

This study shows the significant difference in dust accumulation in *F. carica* and *Psidium guajava* at diverse sites in and around Multan. *F. carica* owing to its extended petioles and broadly ovate foliage had shown the maximum dust accumulation capacity as compared with *P. guajava* which had short- leaves stalks and oblong-elliptic foliage. In addition, large leaf surface area and pubescence degree allow the species to capture more dust particles. Many scientists also observe the impact of leaves traits on dust accumulation (Garg *et al.*, 2000; Younis *et al.*, 2013). Morphological traits such as waxes, epidermal cell margins, trichomes, ledges of stomata give roughness to leaves (Pal *et al.*, 2002). Extra dust accumulation in species growing at road sides may be due to high dust strength which fallout by the vehicles movement and capturing dust, with a calm wind. B.Z. University plants showed minimum dust accumulation because this area has more plantation and less exposed land. Thus, *F. carica* could be one of the significant contributors for reducing dust pollution from air.

Sufficient amount of dust pollution formed a layer on leaves than reduced light capturing ability of leaves which resulted in the declining of photosynthesis and ultimately plant growth (Farmer, 1993). Similar results were pragmatic in this study that dust had significant impact on leaf area of *F. carica* and non significant effect on *P. guajava* because *there* was +ive correlation between dust load and leaf area of *F. carica* while, negative correlation between dust accumulation and area of leaf was observed in case of *P. guajava*.

Many environmental factors control the growth and development of the plants (Katiyar and Dubey, 2000). Disparity in foliage pigments (chlorophyll “a, b, total” carotenoids and ascorbic acid) are may be caused by these factors. Chlorophyll reduction with increasing dust particles was observed because these particles also bring many metals and hydrocarbon (polycyclic) which retard the manufacture of chlorophyll synthesis enzymes (Prajapati and Tripathi, 2008). In our study the ascorbic acid and chlorophyll give different response to dust pollution, as chlorophyll contents decreased and ascorbic acid contents increased with increasing dust pollution (Garg and Kapoor, 1972). Chlorophyll amount in dust contaminated leaves is lesser than control one also reported by numerous scientists (Mandal and Mukherji, 2000; Samal and Santra, 2002). The study clearly recommended that cultivation of *F. carica* in dusty areas can control particulate pollution which may cause hazardous consequences for human health.

CONCLUSION

From the present study it is proved that *F. carica* can accumulate more dust as compared to *P. guajava*. Therefore, it is recommended to cultivate *F. carica* plants in a highly dust polluted areas; it will be helpful in reducing dust concentration in atmosphere and prevent negative impact of dust on living organisms.

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AUTHOR (S) BIOSKETCHES

Younis, U., Ph.D. Candidate; Department of Botany, Institute of Pure and Applied Biology, Bahauddin Zakariya University, Multan, Pakistan. E-mail: *uzma.botany@hotmail.com*

Bokhari, T.Z., Ph.D., Assistant Professor; Department of Botany, Institute of Pure and Applied Biology, Bahauddin Zakariya University, Multan, Pakistan. E-mail: *tzb_5@hotmail.com*

Malik, S.A., Ph.D., Assistant Professor; Department of Botany, Institute of Pure and Applied Biology, Bahauddin Zakariya University, Multan, Pakistan. E-mail: *tzb_s@hotmail.com*

Raza Shah, M.H., M.Sc., Instructor; Department of Botany, Institute of Pure and Applied Biology, Bahauddin Zakariya University, Multan, Pakistan. E-mail: *hzb5@hotmail.com*

Athar, M., Ph.D., Professor; California Department of Food and Agriculture, 3288 Meadowview Road, Sacramento, CA 95832, USA. E-mail: *atariq@cdfa.ca.gov*

Niaz, S., M.Sc., Department of Botany, Institute of Pure and Applied Biology, Bahauddin Zakariya University, Multan, Pakistan. E-mail: *tzb@hotmail.com*

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