Arab J Geosci (2016) 9: 244
DOI 10.1007/s12517-015-2241-5

ORIGINAL PAPER

Investigating and comparing short period impact of dust on physiological characteristics of three species of *Pinus eldarica*, *Cupressus sempervirens*, and *Ligustrum ovalifolium*

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Received: 13 July 2015 / Accepted: 18 November 2015 / Published online: 24 March 2016

Abstract The purpose of this study is to know about the short period response of three green area plants to deposit of dust on the plants and impact on their physiological characteristics. In recent decade, the number of dusty days increased in some parts of Iran because of drought and erosive wind blowing on erodible lands. In this study, three species of *Pinus eldarica*, *Cupressus sempervirens*, and *Ligustrum ovalifolium* were selected. The amount of cumulative falling dust of 1, 2, and 4 g/cm^2 was deposited on samples using a dust simulator in three stages with time interval of 1 week. At the end of each stage, physiological characteristics of the three treatment seedlings and three control seedlings were measured from each species. To further investigate the effect of dust, the position of dust on the leaves of the three plant species was prepared by Scanner Electronic Microscopic (SEM). Measurement results show that dust increase has no significant effect on the physiological parameters of proline, chlorophyll and carotenoids, and soluble sugar of *P. eldarica* and *C. sempervirens* species. But two mechanisms have been used by *L. ovalifolium* plants to compensate for the lack of light absorption. This has increased chlorophyll content and its growth. Increasing dust in *L. ovalifolium* has significant effect on chlorophyll and morphological structures, such as stem length and number of leaves. The results also showed that the amount of soluble sugars did not change by increasing dust. Since the impact of growth factors in this study showed a significant increase with increase of dust, one can conclude that the soluble sugars from photosynthesis have been used for the structure of the three studied plants. According to the study, short period dusting have no effect on *P. eldarica* and *C. sempervirens* species but have significant effect on *L. ovalifolium.*

Keywords Dust · Dust simulator · Proline · Falling dust

This article is part of the Topical Collection on *DUST*

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Introduction

The so-called Third World development model, in addition to economic and social problems, has considerable effects on the environment. Today, reducing and controlling the dust in order to create a sustainable environment is one of the main concerns in achieving an appropriate and sustainable development. Dust as a significant phenomenon in the desert zones causes disorder in human and agricultural activities, social infrastructure, transport, and industries. The large volume of transported particles into the atmosphere affects energy balance, which in turn affects the climate of these areas (Takemi and Seino 2005; Goudie and Middleton 2001). The maximum number of dusty days in Iran occur in Zabol and Dezful cities at about 166 and 188 days per year, respectively. Annual spatial analysis shown that Zabol, Dezful, Yazd, Abadan, Hamadan, and Ahwaz have the high number of dusty days

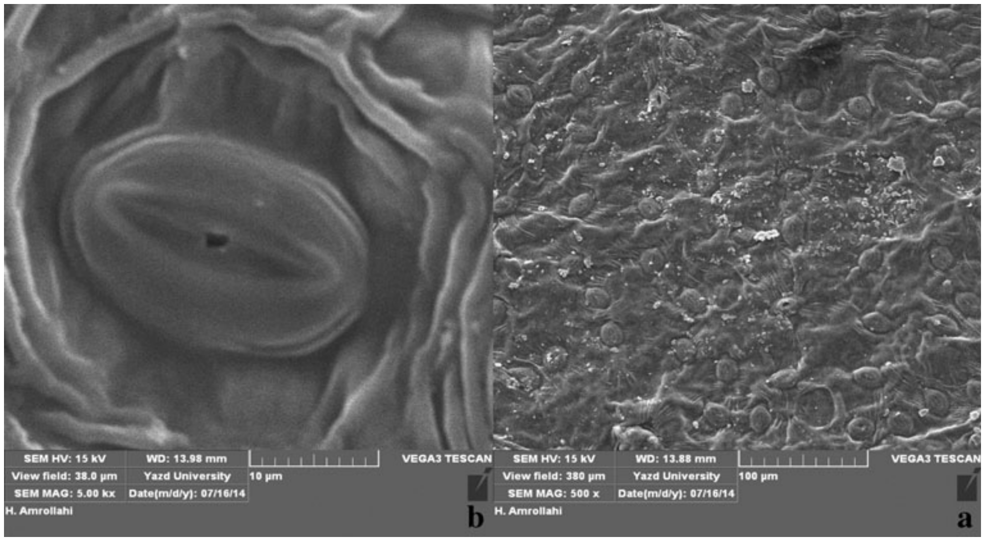

Fig. 1 100 (**a**) and 10 μm (**b**) of back surface of *L. ovalifolium* leaf

annually (Dehghanpor et al. 2014).Vegetation and its kind also play a role in the severity of dust occurrence. Density and structure of plants are two main controlling factors in occurrence and frequency of dust storms (Engestaler 2001). Dust also has a variety of physical and chemical effects on the aerial parts of plant. Limestone dust causes abrasion on the surface of the leaves, changes in the balance energy of the leaves, and may even cause damage because of the alkaline properties of limestone (Grantz et al. 2003). In investigating the effect of the dust particles from the cement factory on diversity and vegetation density, it showed that there is a reverse correlation between the type and density of vegetation with sediment of dust particles out of factory chimneys. (Sadeqiravesh and Khorasani 2008). On the other hand, Kumar and Thambavani (2012) stated that the mortality rate in young branches of leaves in areas at risk of dust is very high. Pollution has effects on the concentrations of chlorophyll *a* and *b*, photosynthesis, and pH on leaves.

Ibrahim and El-Gaely (2012) investigated the effect of cement factory dust on plant species of *Salsola* and showed a very high mortality rate in species around the factory. The amount of chlorophyll *a* and *b* in the examined species close to the factory is more than that for species far from the factory. In general, cement factory dust pollution has effects on photosynthesis dyes, pH, amino acid metabolism, and the sugar rate of the leaves. Studies of Eveling (1969) on utilized leaves of beans,

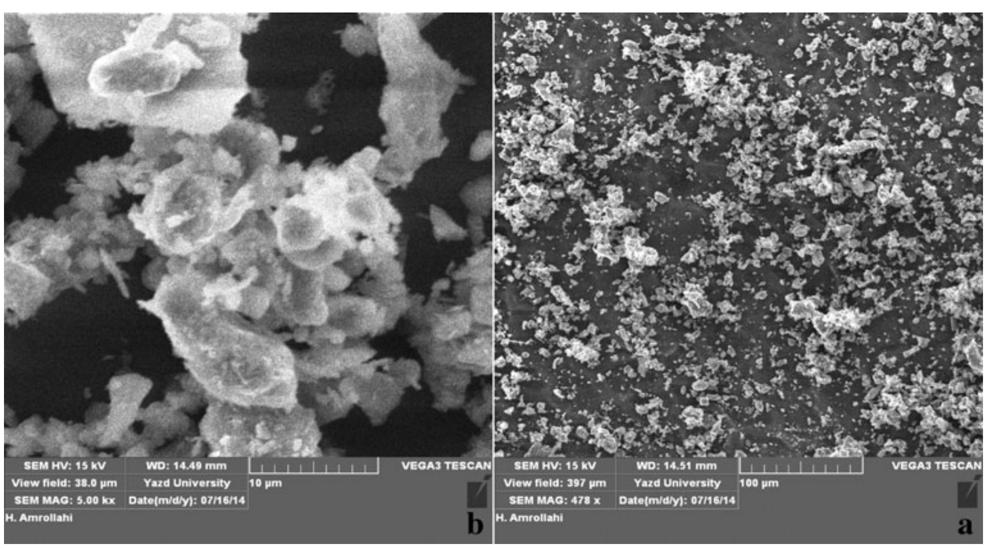

Fig. 2 100 (**a**) and 10 μm (**b**) of the outer surface of *L. ovalifolium* leaf

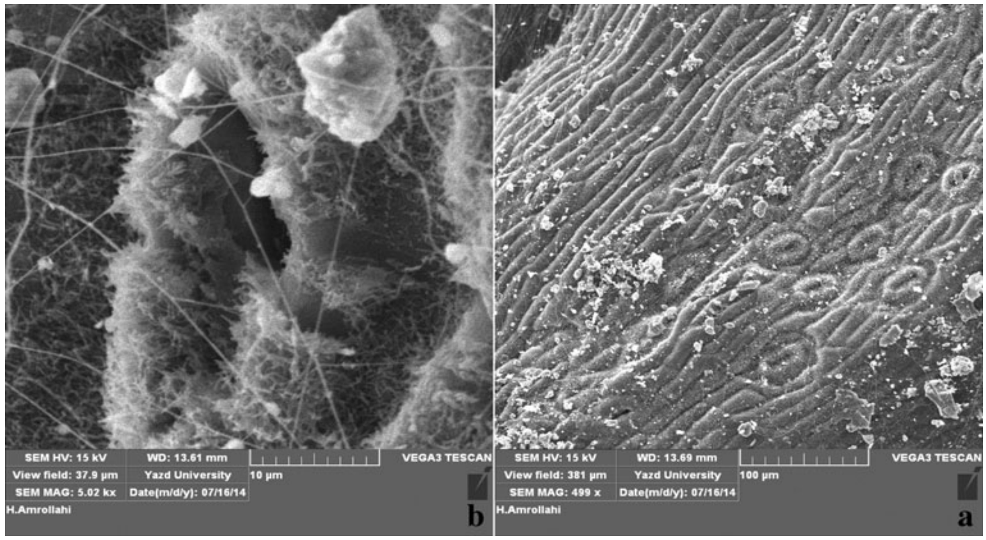

Fig. 3 100s (**a**) and 10 μm (**b**) of back surface of *C. sempervirens* leaf

Solenostemon, and *Zebrio* using inert dust showed that not only the water loss will not increase but it will also have influence on the ammonia. With increase in dust concentration and particles size reduction, the leaves permeability is increased with ammonia. Even less use of factory cement dust revealed effects, such as closure of stomatal and damage to leaves and decreased growth of plant and reproduction of structures, on plants.

Yamaguchi et al. (2012), in reviewing and providing effects of black carbon on growth and change of gas rate in the seeds of plants of Japanese beech, *Castanopsis sieboldii*, Japanese black *Pinus*, and dew *Pinus*, indicated that black carbon particles deposited on the leaf surface reduce photosynthesis rate by increasing shading. The leaf temperature does not increase by absorbing sunlight and does not lead to closure of leaf surface stomata. Black carbon particles have no special effects on plant height and bases of plant diameter during the test and the whole plant dry mass at the end of the experiment. The results show that the use of carbon black particles with a small particle size for two growing seasons has no impact on the changed gas rate of the leaves of Japanese beech, Japanese *Pinus*, dew *Pinus*, and *C. sieboldii*. The results of Nanos and Ilias (2007) on cement dust on the physiological parameters of leaves of the olive tree showed that leaf dry matter concentration and specific leaf weight are increased with the age of the

Fig. 4 100x (**a**) and 10 μm (**b**) of the outer surface of *C. sempervirens* leaf

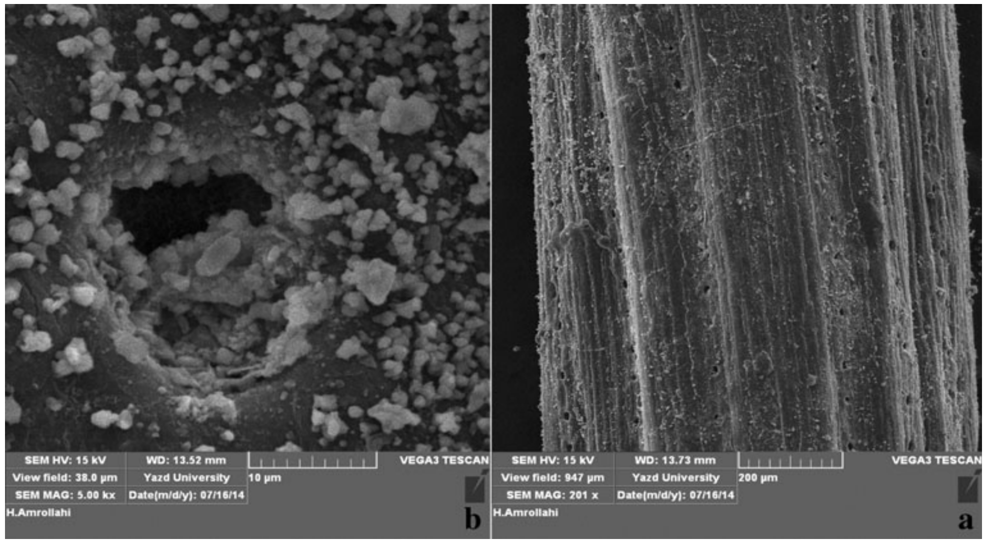

Fig. 5 100 (**a**) and 10 μm (**b**) of the first side of *P. eldarica* treatment

leaf and dust concentration. They mentioned that cement dust decreases the total chlorophyll content and chlorophyll *a* to *b* ratio. In addition, the rate of photosynthesis and quantum yield is reduced. Transpiration rate slowly decreases, leading to reduced pore for the displacement of water and carbon dioxide. The concentration of internal carbon dioxide remains constant and leaf temperature increases. Oran and Abuzahra (2014) research results in using scanning electron microscopy on dust revealed that different dusts have been deposited on the surface of the various sampled leaves.

The purpose of this study is to investigate the short period response of three selected plant species to dusts. Given the widespread destruction of the environment and increased dust and its health effects on human health, introduction and planting appropriate plants in urban green spaces may help to alleviate the problems of today's leading human ignorance.

Materials and methods

Preparation of dust

In order to produce dust, soil samples from Yazd-Ardakan plain geomorphologic faces susceptible to wind erosion were used. Some soil samples were collected and poured into the sieve device and were passed from 63 μm sieve. The remaining amount of dust under 63 μm sieve was used.

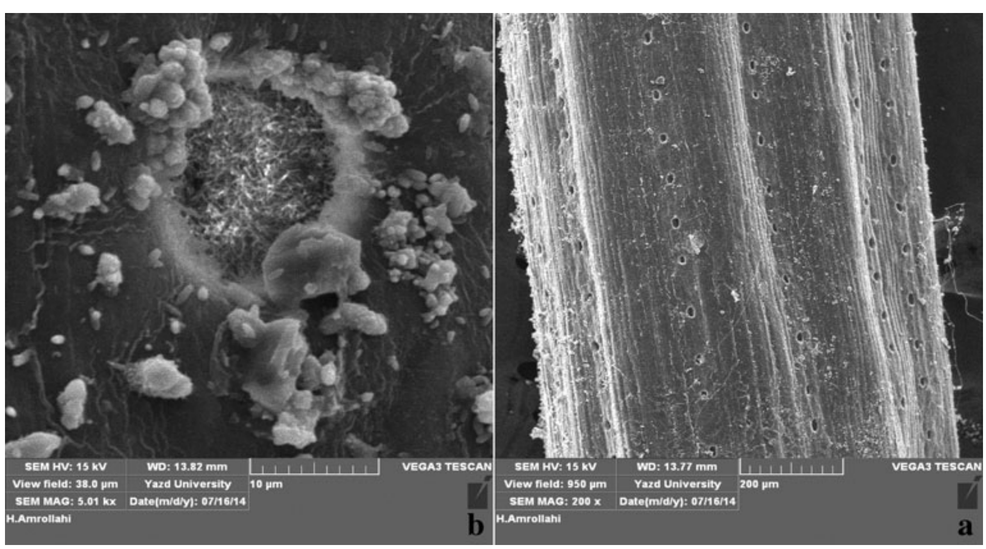

Fig. 6 100 (**a**) and 10 μm (**b**) of the second side of *P. eldarica* treatment

Table 1 Analysis of dust samples by XRF

Formula combination	Concentration (%)	Formula combination	Concentration (%)
Sb_2O_3	0.000013	TiO_2	0.725
SnO_2	0.000019	Na_2O	0.95
Rh	0.00016	Fe_2O_3	2.1
CdO	0.0002	K_2O	2.6
Ag	0.00024	MgO	4.97
Cl	0.042	CO_2	9.1
SO_3	0.15	Al_2O_3	12.6
P_2O_5	0.22	CaO	18.01
SiO_2	48.8		

Studied species

Investigating the effect of dust on plant species was done in the greenhouse located in the eastern site of Yazd University. Three species of *Pinus eldarica*, *Cupressus sempervirens*, and *Ligustrum ovalifolium* Yazd were taken from the nursery in Yazd.

(a) *P. eldarica: P. eldarica* is from the Pinaceae family. Slightly rough and green leaves, fruit cone is in different shapes and sizes. *P. eldarica* is so valuable for forestry and tree planting in semi-arid regions of our country, and given the extraordinary ability to withstand such heat and extreme cold, its value becomes more apparent. Its roots that keep the tree in place are deep at windy places and allow exploitation of deep soil moisture in dry areas for the tree. The branches are thick and relatively long (Jazireyi 2010).

(b) *C. sempervirens* var. *cereiformis: Cupressus* tree is evergreen. Its root is extensive that keeps the tree on soil in a solid way. *C. sempervirens* is dry-oriented, such that it is flexible to moisture and able to grow relatively at humid environments (Jazireyi 2010).

(c) *L. ovalifolium:* The scientific name is privet *L. ovalifolium*. It has several types, and all of them are usually green and have permanent leaves and it is used to decorate gardens. Its leaves are large, glossy, dark color, and permanent, and are planted in gardens of the country (Sabeti 2008). This evergreen shrub is often used in parks, boulevards, and squares, and sometimes as a hedge to be planted in courtyard of houses (Mozaffarian et al. 2000).

Dusting by a dust simulator

When investigating the effect of the three studied species, dust injection was used in three phases with dust simulator. This device has a dust storage compartment, the section of mixing of dust with air and its homogenization, and the dusting chamber. The amount of falling dust was measured using a special tray at the bottom of the machine and the PM_{10} was controlled by dust meter at every stage of dusting. Dusting was done in a month with an interval of 1 week. After each time of the dusting of each species with three repeats (three control seedlings and three treatment plants), they were transferred to the laboratory to measure the physiological parameters, such as proline (Bates et al. 1973), chlorophyll and carotenoids (Lichtenthaler 1987), and soluble sugar (Kochert 1978) .

Scanning electron microscope

Ten milliliters of the control and treatment leaves samples of any species were placed in the vacuum conditions using sputtering device. This device, in addition to

Table 2 Analysis of variance of dusting effect on physiological traits (chlorophyll *a*, *b*, total, and carotenoids) of three species of *P. eldarica*, *C. sempervirens*, and *L. ovalifolium* (cumulative falling dust 1 g/cm^2)

Change resources	Freedom degree	Chlorophyll *a*	Chlorophyll *b*	Total chlorophyll	Carotenoids
Dusting	1	54.6*	18.3 ns	139.5*	0.3 ns
Species	2	293.4**	20.3 ns	538.93**	7.98*
Dusting of species	2	25.7 ns	3.8 ns	50.45 ns	0.83 ns
Error	12	11.14	9.84	24.11	1.48

ns not significantly different

**Significantly different at 0.01 levels; *significantly different at 0.05 levels

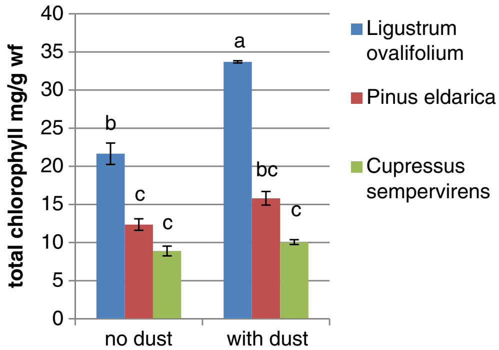

Fig. 7 Comparison effect of dusting on total chlorophyll content (1 g/cm^2)

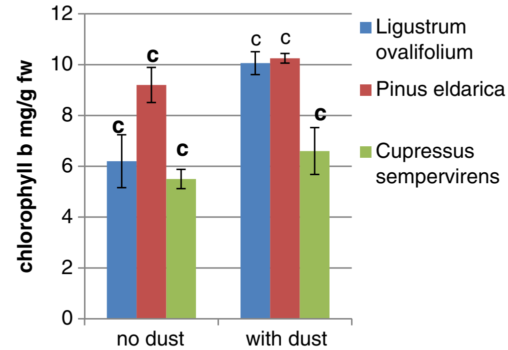

Fig. 9 Comparison effect of dusting on chlorophyll *b* content (1 g/cm^2)

killing the living tissues of a plant, creates golden cover on them. Then, the microscopic images on a scale of 100 and 10 μm from the samples were prepared using a scanning electron microscope (SEM) (Figs. 1, 2, 3, 4, 5, and 6). The images were to evaluate and interpret the stomatal of the leaves and the dust on the surface of the leaves.

Statistical analysis

Data analysis was performed using Statistical Package for Social Science (SPSS) version 16 and drawing charts was done in Excel software. Analysis of data was performed using analysis tests and two-way analysis of variance (ANOVA), and the difference of averages was calculated using Duncan test ($\alpha = 0.05$).

Results

Analysis of dust used in the simulation device showed that dust has a pH at extract of 1:5 in the range of 7.01 ±0.75, electrical conductivity (EC) of 0.34 ± 0.15 dS/m, and lime of 18.75 ± 5.1 %. On the other hand, the analysis of the used dust sample in this study by using X-ray fluorescence (XRF) device showed that the highest concentrations of the compounds is for SiO_2, CaO, and Al_2O_3, respectively (Table 1).

The results of the first stage of dusting on physiological traits, such as chlorophyll *a*, chlorophyll *b*, total chlorophyll, and carotenoids, are shown in Table 2 and Figs. 7, 8, 9, and 10. In this stage, the amount of falling dust is 1 g/cm^2, and the average of PM_{10} during dusting is 61.03 μg/m^3. The results of ANOVA of physiological characteristics of species of *C. sempervirens*, *P. eldarica*, and *L. ovalifolium* showed that in the first stage of dusting, dusting effect on chlorophyll *a* and total chlorophyll was significant. The results also showed that the effect of species on factors chlorophyll *a*, carotenoids, and total chlorophyll was significant. Interaction effect of dust species had no significant effect on any of these factors.

In the second stage dusting, the cumulative falling dust is measured to be 2 g/cm^2 and the average of suspended dust (PM10) is 60.67 μg/m^3. The results of ANOVA of the physiological characteristics of species of *C. sempervirens*, *P. eldarica*, and *L. ovalifolium* indicated that dusting effect was not significant on any of

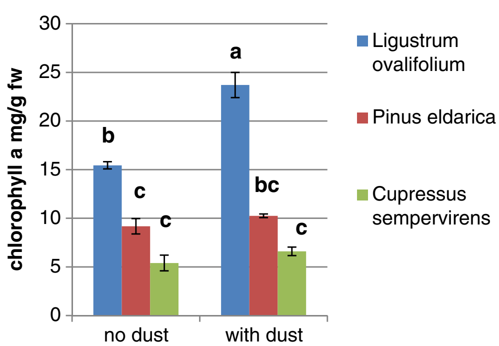

Fig. 8 Comparison effect of dusting on chlorophyll *a* content (1 g/cm^2)

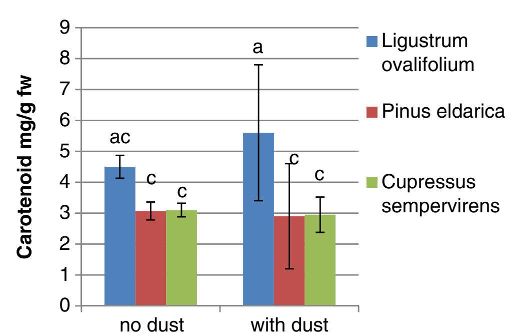

Fig. 10 Comparison effect of dusting on carotenoid content (1 g/cm^2)

Table 3 Analysis of variance of dusting effect on physiological traits (chlorophyll *a*, *b*, total, and carotenoids) of three species of *P. eldarica*, *C. sempervirens*, and *L. ovalifolium* (cumulative falling dust of 2 g/cm^2)

Change resources	Freedom degree	Chlorophyll *a*	Chlorophyll *b*	Total chlorophyll	Carotenoids
Dusting	1	794.0 ns	0.166 ns	0.938 ns	0.002 ns
Species	2	176.06**	27.26**	325.69**	6.92 ns
Dusting of species	2	64.1**	10.09*	120.64**	1.80 ns
Error	12	7.25	2.47	17.74	2.62

ns not significantly different

**Significantly different at 0.01 levels; *significantly different at 0.05 levels

the studied factors in the second stage dusting. The results also showed that the effect of species on factors of chlorophyll *a*, *b* and total was significant at 1 % level. The interaction effect of species and dust on chlorophyll *a* and total chlorophyll is significant at 1 % level and on chlorophyll *b* is significant at 5 % level (Table 3 and Figs. 11, 12, 13, and 14). When comparing the results of the data average in the second phase of dusting using Duncan method, it showed that the highest rate of chlorophyll *a* in *L. ovalifolium* was 22.1 mg/g fresh weight and the lowest level of it in treatment in *P. eldarica* was 6.4 mg/g fresh weight. The results also showed that the highest chlorophyll content is in the *L. ovalifolium* with the rate of 30.67 and it is lowest in *P. eldarica* with the rate of 8.69 mg/g fresh weight. Most chlorophyll *b* is with the rate of 8.87 mg/g in *L. ovalifolium* and 2.28 mg/g fresh weight in *P. eldarica*. From the plants studied, only *L. ovalifolium* plants have significantly increased its chlorophyll *a*, *b* and total chlorophyll in the cumulative falling dust of 2 g/cm^2.

In the last stage, the cumulative falling dusting is 4 g/cm^2. The average suspended dust (PM_{10}) is 44.04 μg/m^3. Dusting effects on all factors of chlorophyll *a*, *b*, total, and carotenoids are significant. The results also showed that the effect of species on carotenoids' factor is significant at 5.0 % level. The interaction effect of species and dust on any of the factors was not significant (Table 4 and Figs. 15, 16, 17, and 18).

Comparing the results of the data average showed that the highest level of carotenoids in *L. ovalifolium* is 4.75 mg/g fresh weight and the lowest rate is in *P. eldarica* control by 2.69 mg/g fresh weight, respectively. From the plants studied, only *L. ovalifolium* species with cumulative falling dusting of 4 g/cm^2 has increased it carotenoids significantly.

The results of ANOVA of physiological characteristics of species of *C. sempervirens*, *P. eldarica*, and *L. ovalifolium* indicated that the cumulative falling dusting is 1 and 2 g/cm^2, and the effect of species on the proline rate was significant at 5 and 1 % level, respectively. The results also showed that the dusting and interaction effect of species and dusting on proline rate was not significant at none of the stages (Table 5 and Figs. 19, 20, and 21). The results of data average comparison in the three steps of dusting using Duncan method on the proline rate have no significant effect.

The results of ANOVA of physiological characteristics of species of *C. sempervirens*, *P. eldarica*, and *L. ovalifolium* indicated that the cumulative falling dust is 1 g/cm^2 and the effect of species on the amount of soluble sugars was significant at 1 % level. The results also showed that dusting and the interaction effect of species and dusting in none of the dusting

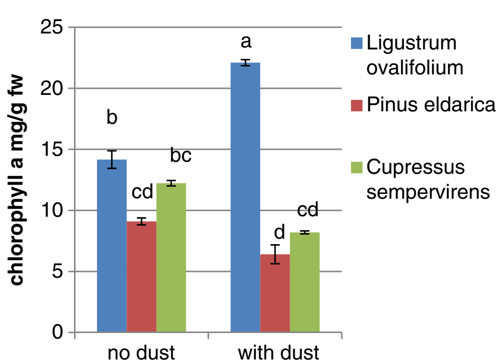

Fig. 11 Comparison effect of dusting on chlorophyll *a* content (2 g/cm^2)

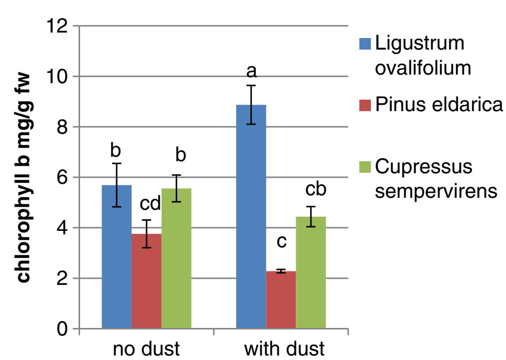

Fig. 12 Comparison effect of dusting on chlorophyll *b* content (2 g/cm^2)

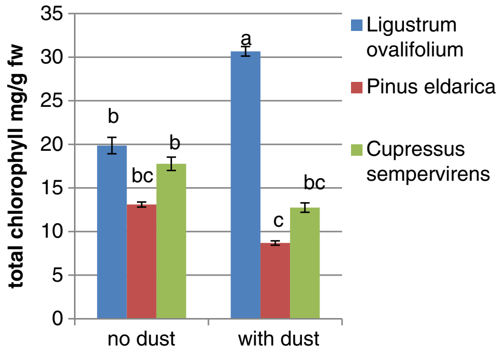

Fig. 13 Comparison effect of dusting on total chlorophyll content (2 g/cm^2)

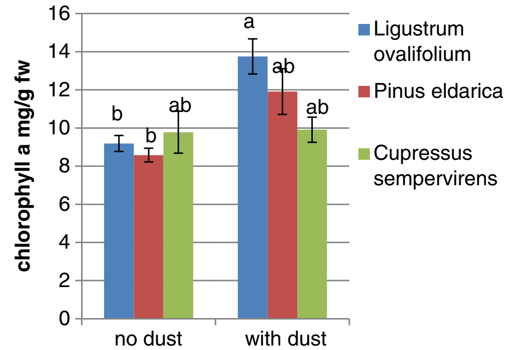

Fig. 15 Comparison effect of dusting on chlorophyll *a* content (4 g/cm^2)

stages has no significant effect (Table 6 and Figs. 22, 23, and 24). Results comparison of data average at three dusting phases in Duncan method has no significant effect on the amount of proline.

Figures from microscopic images taken from outer and back surfaces of the control and treatment leaves showed that the stomatal of the outer surface of *L. ovalifolium* are placed next together very regularly and small. As shown in Figs. 1 and 2, dust has covered the *L. ovalifolium* stomatal completely and regularly has covered all surfaces of the leaf. But when compared with the outer surface, the back surface of *L. ovalifolium* (Fig. 1) has less dust. The results of

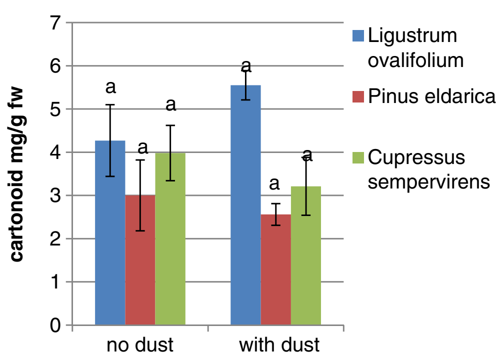

Fig. 14 Comparison effect of dusting on carotenoid content (2 g/cm^2)

chlorophyll tests showed that its amount has been increased in *L. ovalifolium* leaf. Since the stomatal of the beneath surface of *L. ovalifolium* leaves are open, the plant is able to breathe, transfer oxygen and carbon dioxide, and so can photosynthesize, and the outer surface dust only has a shade on leaf, but since the beneath surface stomatal are without dust, the plant can extend the length of stem, diameter, and increase the number of leaves (Fig. 2). The stomatal are fully open and intact, and the plant can grow.

The results of microscopic images of *C. sempervirens* under the effect of three dusting stages during 1 month showed that the dust on the back and outer surface of the *C. sempervirens* has been dispersed and whole of its surface has been exposed to dust. As the image (Fig. 3) of the back surface of *C. sempervirens* treatment shows, dust has covered both sides of the leaf. Deposition of dust on stomatal surface and the time dust remains on leaves have become the intended species because of reduced defensive power (Fig. 4). Dust cultivation causes the closure of stomatal, reduces the leaf power to photosynthesize, and leads to the reduction of chlorophyll *a* and *b* concentration. However, despite of deposition of dust on *C. sempervirens* leaf surface, its chlorophyll has not changed so much in all dust stages.

The results of microscopic shots of *P. eldarica* samples showed that image 100 and 10 μm (Figs. 5 and 6) in relation to the back surface of *P. eldarica* has been filled with dust in

Table 4 Analysis of variance of dusting effect on physiological traits (chlorophyll *a*, *b*, total, and carotenoids) of three species of *P. eldarica*, *C. sempervirens*, and *L. ovalifolium* (cumulative falling dust 4 g/cm^2)

Change resources	Freedom degree	Chlorophyll *a*	Chlorophyll *b*	Total chlorophyll	Carotenoids
Dusting	1	32.21*	11.99**	83.56**	2.33*
Species	2	4.29 ns	1.69 ns	11.02 ns	1.81*
Dusting of species	2	7.84 ns	2.59 ns	19.59 ns	0.55 ns
Error	12	4.61	0.74	8.48	0.35

ns not significantly different

**Significantly different at 0.01 levels; *significantly different at 0.05 levels

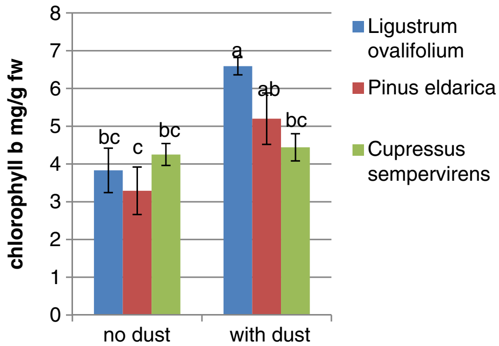

Fig 16 Comparison effect of dusting on chlorophyll *b* content (4 g/cm^2)

scattered way. But needle leaves' proline, chlorophyll, and soluble sugar have not changed because of resistance and late growth. The first and second sides of *P. eldarica* leaves like *C. sempervirens* samples have been filled with dust nut at any case. The measured factors' rate has not changed and is not significant.

Discussion and conclusion

Dust by blocking the stomatal of the leaf area prevents gas exchanges of the stomatal and leads to death of plant cell tissues. Dust reduce conductance of stomatal in the light and increases it in the dark due to closure of stomatal. Dust reduces the rate of photosynthesis by creating a cover (cause shading on surface of leaf) on the leaf surface. Increased absorption of sunlight by dust on the surface of the leaf increases the plant temperature and creates changes in the photosynthetic rate. The results of this study with a choice of three types of high culture, especially in urban areas, seek the introduction of appropriate species in urban structure with respect to the increased dust. The results of the analysis of the samples showed that increased dust causes significant increase of chlorophyll *a* and total chlorophyll content in *L. ovalifolium*, but had no significant effect on other plants. Many of the plants react in different light intensities by increasing the amount of chlorophyll in the leaves. Dust increase on the leaves reduces light absorption in the leaves. For plant to compensate, there is need for an increase in chlorophyll and other vertical structures. *L. ovalifolium* species, because it reduces light absorption by loading the dust on the surface of their leaves, has increased the chlorophyll content and

Table 5 Analysis of variance of dusting effect on physiological traits of proline of three species of *P. eldarica*, *C. sempervirens*, and *L. ovalifolium*

Change resources Cumulative falling dust	Freedom degree	Stage 1 1 g/cm^2	Stage 2 2 g/cm^2	Stage 3 4 g/cm^2
Dusting	1	48.15 ns	12.17 ns	72.64 ns
Species	2	2170.2*	128.71**	49.31 ns
Dusting of species	2	39.63 ns	8.10 ns	48.26 ns
Error	12	491.46	15.88	37.70

ns not significantly difference

**Significantly difference at 0.01 levels; *significantly difference at 0.05 levels

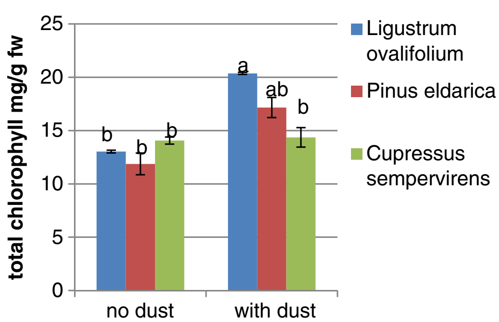

Fig. 17 Comparison effect of dusting on total chlorophyll content (4 g/cm^2)

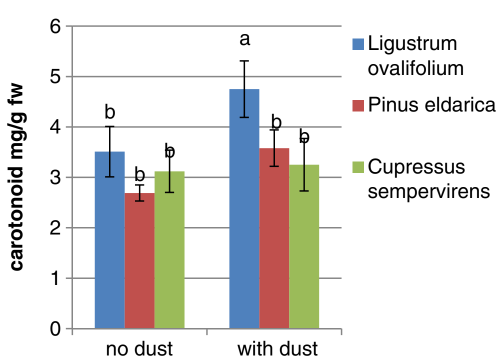

Fig. 18 Comparison effect of dusting on carotenoid content (4 g/cm^2)

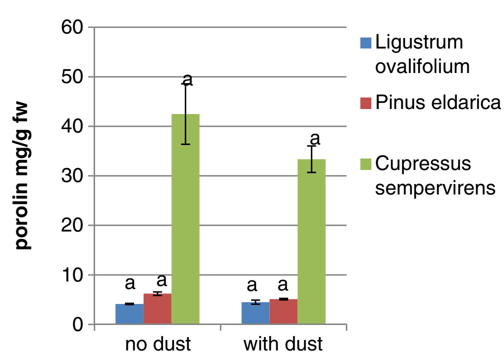

Fig. 19 Comparison effect of dusting on proline (1 g/cm^2)

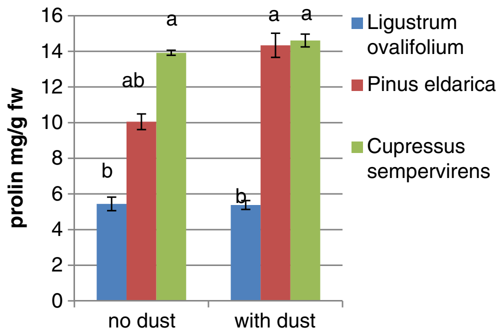

Fig. 20 Comparison effect of dusting on proline (2 g/cm^2)

the number of leaves and stem length. Similar to this study is the results of Hirano et al. (1994), if the applied light intensity on the surface of dusted leaves is greater than the saturation point of light, dust cannot reduce the rate of photosynthesis by shading. Research results of Kumar and Thambavani (2012) and Farmer (1993) showed that dust affects photosynthesis rate and transpiration because of the accumulation of dust on the plant surface that are raised as the physical effects of dust. The physical effects of dust loaded on the surface of the leaves consist of stomatal closure, shading, increased temperature of leaves and removal the cuticle wax, reduced growth and production of plants, reduced photosynthesis, and ultimately would lead to cell death or the dried plant, which is in contrasts with the results of Zia-Khan et al. (2012). A 30 % reduction in the stomatal conductance of the dust-treated plants as compared to the control plants shows the blocking of the stomata on the top leaf surface due to the shading effect caused by the dust layer, which decreased the overall net photosynthesis rate soon after the dust was applied. Similar results were reported by Singh and Rao (1981), where the transpiration rate was decreased by 22 % as a result of cement dust on wheat plants. They concluded that cement crust reduces the light reaching the leaf surface and, thereby, decreases the thermal balance of the leaf.

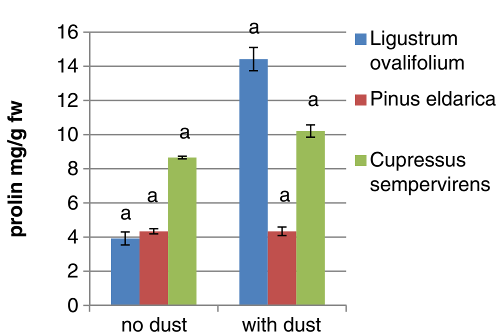

Fig. 21 Comparison effect of dusting on proline (4 g/cm^2)

Table 6 Analysis of variance of dusting effect on physiological traits of soluble sugar of three species of *P. eldarica*, *C. sempervirens*, and *L. ovalifolium*

Change resources	Freedom degree	Stage 1	Stage 2	Stage 3
Cumulative falling dust		1 g/cm^2	2 g/cm^2	4 g/cm^2
Dusting	1	2.51 ns	0.06 ns	0.025 ns
Species	2	8.57**	0.23 ns	5.3 ns
Dusting of species	2	1.47 ns	2.49 ns	0.66 ns
Error	11	1.01	0.98	1.9

ns not significantly difference

**Significantly difference at 0.01 levels; *significantly difference at 0.05 levels

Analysis of soluble sugar content in the plant did not get significant. Due to dust increase, absorption of intensity of sunlight may reduce photosynthesis. Photosynthesis reduction leads to decreased synthesis of sugar, and in this case, the plant will grow less than other plants (Seyyednejad et al. 2011). The concentrations of total sugar content were markedly decreased with increase in pollution load. But in this research, it does not seem that the amount of photosynthesis in the three studied species has declined because lack of light intensity was compensated with the synthesis of chlorophyll content. Therefore, there should be no significant difference in the amount of soluble sugars. The results also showed that by increasing the amount of dust, soluble sugars did not change. Since the growth factors effect in this study showed a significant increase with increase in dust, one can conclude that soluble sugars from photosynthesis has been used for the structure of the three studied plants. The results showed that the amount of proline did not have a significant change by increasing dust. Since the growth factors effect in this study showed a significant increase with increase in dust, one can conclude that the soluble sugars from photosynthesis have been used for the structure of the three

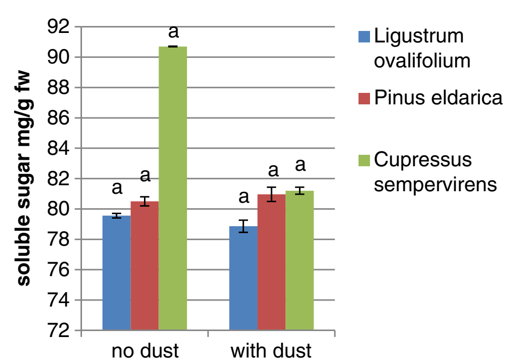

Fig. 22 Comparison effect of dusting on soluble sugar (1 g/cm^2)

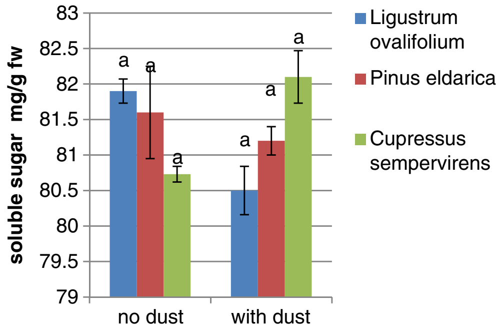

Fig. 23 Comparison effect of dusting on soluble sugar (2 g/cm^2)

studied plants. Also, the results showed that the amount of proline had no significant change by increasing dust. The balance between nitrogen and carbon in plants for plant growth stages is very important. Nitrogen is changed into amino acids and proteins in metabolism revival of nitrate. In general, in plants that absorb more nitrogen, the amount of hydrocarbons in the plant is reduced, and on the contrary, when the amount of nitrogen in the plant is reduced, the amount of hydrocarbons increases. The balance between these two can have an important role in vegetative and reproductive stages. When nitrogen comes into amino acids molecules and is consolidated, some of the metabolic materials of cycle tri-carboxylic acid (TCA) are consumed, but continuum of the TCA cycle action needs to be filled instead of the said used metabolic materials. Supplying and filling of the place of these metabolic materials cause the consumption of hydrocarbons and its derivatives. These compounds provide carbon skeletons for synthesis of amino acids; thus, mineral N reduces the reserves of carbohydrates in plant (Noggle and Fritz 1983). Since the amount of sugar in the tested plants did not show that it seems this performance has had no effect on the amount of proline amino acid, these results are inconsistent with studies of Dellaa et al. (2012). They stated

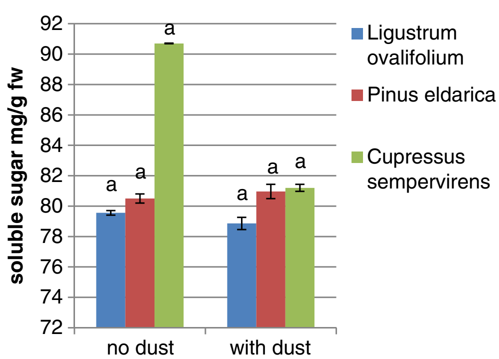

Fig 24 Comparison effect of dusting on soluble sugar (4 g/cm^2)

that *P. eldarica* and *C. sempervirens* are very sensitive to chronic exposure to cement dust.

The two species of *P. eldarica* and *C. sempervirens*, which are evergreen species with respect to dust deposit on the leaves and stomatal closure, did not show any reaction to the rising of the dust. Analysis results of psychological factors showed that chlorophyll and proline and soluble sugar of the two species have not changed. In different plant species, especially trees, stomatal are often in the underside of the leaves. When the top and bottom surface are polluted with dust, the plant is with the largest interaction. The results of this study are contradictory with Mandre et al. (2000) study results, which showed that alkaline dust reduces the height of trees and root length and decreases its biomass. Alkaline dust on trees causes serious distortions in the needle composition of young leaves. The highest concentrations of calcium and potassium are in needle leaves of infected trees. The results of this study show that broad leaves are better than conifers in attracting dust, and it is recommended that in places where the dust is low, the broadleaves should be used. Since the negative effects of dust in *L. ovalifolium* are more in places where dust is more, conifers should be used to create green spaces.

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