Limestone Dust as an Abiotic Disease Factor Affecting Vegetables and Olives in Palestine

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Abstract

An experiment was carried out in 2011 to study the effect of limestone dust of quarries on agricultural crops of vegetables and olive trees. The effect of such dust on vegetables including tomato and pepper plants was studied in the open fields of the Arab American University of Jenin (AAUJ). In addition, the effect of such dust was studied on olive orchards nearby quarries in Qabatya region. The Two-Sample Test of Proportions (TSTP) was used as a statistical method to analyze data obtained from the studied regions. The results showed that plant exposure to dust causes drastic negative effect on leaf surface area and productivity for both vegetable crops and olive trees. Chlorophyll content and flowering percentages of pepper plants decreased with increasing the amount of dust. Furthermore, the results revealed that long-term exposure of olive trees to dust decreases oil productivity by 55.3-84.4% and minimizes the percentage of seed maturity and germination percentages.

Keywords: Limestone dust, Olive trees, Vegetable, Palestine.

Introduction

Limestone quarries of Palestine are excavations or open pit mines, from which big pieces of stones are obtained by mechanical cutting. In such quarries, mechanical sub cutting, shaping and finishing of building stones are also done (Makhool and Abu-Alrob, 1999) (Fig. 1).

The industry of stone is the main extractive industry in Palestine. It plays a major economic role in term of production, employment and export. The amount of exported building stones in 2013 was 132.918 million dollars which comprises 9.93% of the total exported product in Palestine (Paltrade, 2014). Such industry is one of the Palestinian industries that plays an important role in meeting the domestic demand of the construction sector and in national Palestinian exports.

Palestine is ranked 12th in the world in terms of stone production; it produces 22 million square meters of stone products annually and the worker productivity in this sector is five times higher than other sector (WAFA INFO. 2011a).

Air pollution has become a major threat to the survival of plants in the industrial areas (Gupta and Mishra, 1994). Rapid industrialization and addition of the toxic substances to the environment are responsible for altering the ecosystem (Mudd and Kozlowski, 1975; Mlitan *et al.*, 2013; Clayton and Clayton, 1982). The main atmospheric pollutants are: SO_2, NO_x, O_3, heavy metals and dust. Increased concentration of the above pollutants causes progressive reduction in the photosynthetic ability of leaves, closure of leaf stomata and mainly, reduction in growth and productivity of plants (Singh *et al.,* 2014).

Environmental contamination due to dust particle coming often from quarries has drown much attention to the environmental scientists today as they create serious pollution problems and pose threat to the ecosystem. These dust particulates are causing large scale deforestation destruction of Biota and other natural resources (Panda, 1996). Such pollution has been described as an additional stress on plants since they often respond to atmospheric contamination in the same way as they respond to drought and other environmental stress. The role of those pollutants causing injury to plants either by direct effect or modifying the host physiology rendering it more susceptible to infection (Raajasubramanian *et al.,* 2011).

Dust can have both chemical and physical effects on plants. In severe case of pollution, the injury symptoms were expressed as folia necrosis or completely disappearance of the plant. However, plants coated dust are expected to mainly display symptoms of stemming from leaf shading, and increased leaf temperatures, such as inhibition of transpiration, reduced photosynthesis, increased water loss, reduced vegetative and reproductive growth, and reduced fruit set (Eveling, 1969; Eller, 1977; Farmer, 1993; Sharifi *et al.,* 1997). Dust consists of solid matter in a minute and fine state of subdivision so that the particles are small enough to be raised and carried by wind. The main composition of dust is calcium carbonate which is used as tempering agent. The growth of quarrying and open cast mining suggests the dust deposition on vegetation may be increasing.

In Palestine, quarries are established in the rural area and mostly beside agricultural fields because of the limited industrial area of the country and population crowdedness and the high price of land in urban area (Fig. 1). The present research aims to invest the hazardous effect of dust from limestone quarries on olive trees and vegetable crops including its effect on chlorophyll content, vegetative growth and productively of both crops. In addition, the percentage of seed germination of olive trees exposed to dust.

Fig. 1. Quarries established in the rural area beside agricultural fields.

Materials and methods:

Research plan:

This research was divided into two parts. The first part was carried out on fields grown with olive trees *(Olea europaea* L.*)* near the town of Qabatya. This town is about 6 km North East of Jenin City. The second part was done on pepper and tomato plants in the open fields of the AAUJ campus.

Effect of dust on olive trees:

Effect of dust pollution on olive groves was studied within certain proximity of limestone quarry established in Qabatya region during October, 2011. Four sampling sites of olive trees were selected around the quarry as described in Table (1).

Table 1. Location of each site at which sampling was done

The site	Location
S1	Adjacent to the quarry on the eastern site
S2	Adjacent to the quarry on the northern site
S3	Adjacent to the quarry on the southern site
S4	Control sample free of dust

Sampling was done between 10.00-11.00 am. During this period the weather conditions were sunny and dry and almost identical in each day. Polluted leaves of olive trees were collected randomly and prepared for lab testing. Plant yield/hectare, leaf surface area, chlorophyll content, and seed germination were studied as pointed below.

Effect of dust on tomato and pepper plants:

Tomato and pepper plants were divided into three groups and planted during the spring of 2012 in the open fields of the AAUJ campus. Those fields were enriched with organic fertilizers; and planted with same age plants. The first group of plants was used as a control sample (T_0 for tomato and P_0 for pepper). The second group was treated with 0.543 g of dust per 50 cm^2 of leaf area (T_1 and P_1). The third group was treated with 1.754 g/50 cm^2 (T_2 and P_2). Dust was deposited on assay plants using a home-made dusting tool (Fig. 2).

The amount of deposited dust on the plants was determined by random picking of leaves from both pepper and tomato plants. The picked leaves were then washed off with 10 ml distilled water. The washings were collected in the clean pre-weighed beaker then evaporated to determine the weight of dust as g/cm^2. The leaf area was calculated as pointed below. The processes of picking leaves, washing and evaporating were repeated twice at 60 minutes interval between each process. Laboratory analysis was done on the triplicate samples afterwards. Plant yield, and leaf surface area for both of plants were measured. In addition, chlorophyll content of pepper and flowering percentage were studied as pointed below.

Fig 2. Dusty samples of pepper (A) and tomato (B) plants.

Plant yield:

Mature fruits were collected regularly from tomato and pepper plants and weighed for fresh weight using a digital balance. For olive trees, oil production data was collected from farmers and owners of olive orchards in the study site.

Leaf surface area:

Leaf surface area was measured using the tracing technique according to Ferris *et al.*, (2001). Paper replica of the surface was compared with the standard data using the following equation:

Leaf area (mm^2) = weight of leaf tracing (g) x conversion factor (mm^2 gm^{-1}).

Chlorophyll content:

The amount of chlorophyll in the leave was determined in accordance with Beer's-Lambert law (A = εbC), where "A" is the absorbance, "ε" is the extinction coefficient, "b" is the path length and "C" is the concentration, described by Mohr and Schopfer, (1995). Leaves were extracted first with 80% acetone aqueous solution. Then the extracts were incubated at ^{o}10 degree Celsius. Total chlorophyll content was measured at 646, 663 and 750 nm wavelengths using a Perkin-Elmer's spectrophotometer (Lichtenthaler and Welburn, 1983).

Germination experiment of olive seeds:

One hundred olive fruits were collected from olive trees exposed to dust in S1 site. The fruits were soaked in 3% Sodium hypochlorite for 12 hours then the pulp was removed using water and sand (Tezuka, *et al.*, 2012). After cleaning, the seeds were soaked in water for 10 days and planted in an organic soil. Fruits from olive trees far from quarry (S4) were treated in the same way to represent the control data of the experiment. After 40 days of being planted, germination occurred.

Statistical analysis:

Statistical analysis of the data was done using the Two-Sample Tests of Proportions (TSTP) to compare treatments in the studied regions. The results were analyzed using a level of significance when ά = 0.05 (Ott, 1984; Lind *et al.*, 2005; Montgomery, 2008). The following equations were used.

$$z = \frac{\left(\hat{P}_1 - \hat{P}_2\right)}{\sqrt{\hat{P}(1-\hat{P})(\frac{1}{n_1} + \frac{1}{n_2})}}$$

Two – Proportion Z- test, pooled for $H_0 : P_1 = P_2$

$$\hat{P} = \frac{X_1 + X_2}{n_1 + n_2}$$

α, the probability of Type I error (rejecting a null hypothesis when it is in fact true).

n = sample size.

n_1 = sample 1 size.

n_2 = sample 2 size.

$\hat{P} = \frac{X}{n} = sample\ proportion$

P_0 = hypothesized population proportion.

P_1 = proportion 1.

P_2 = proportion 2.

Results:

1-Effect of dust on olive trees:

Plant yield:

The researchers hypothesized that exposure of plants to dust for long periods of time may negatively influence the productivity of olive trees. Compared with S4, the negative impact on olive trees average production in the last three years amounted to 44.7%, 24.6% and 15.6% for fields of S1, S2, and S3 respectively (Fig. 3 and 4). Statistical analysis revealed significant differences between these fields in the years 2008 and 2010.

Fig. 3. Heavily dusty olive tree close to a quarry in Qabatya region.

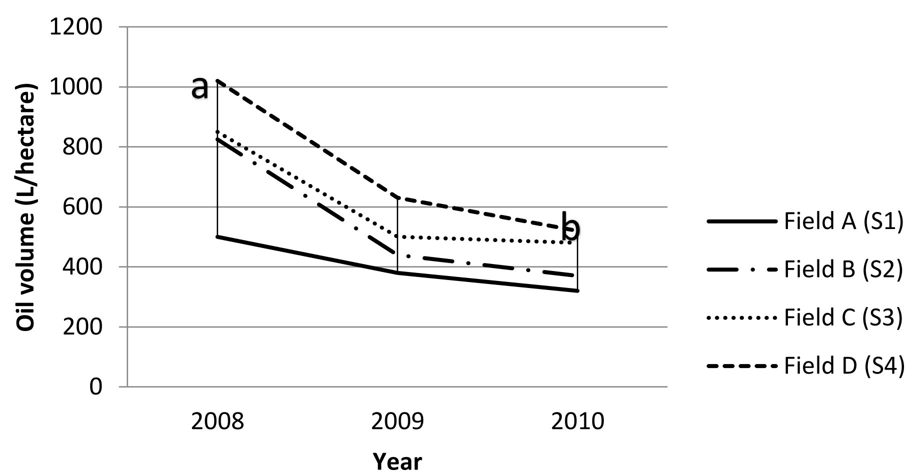

Fig 4: Oil production of olive orchards

***Similar letters means no significant difference**

Leaf surface area:

Dusted olive orchards also reveal lower leaf surface area than undusted trees (Fig. 5). Reduction in leaf surface area decreased as the distance between the limestone quarry and the sites selected for the study increased. Statistical analysis showed that both S1 and S2 have significant differences with the other fields (Fig. 5).

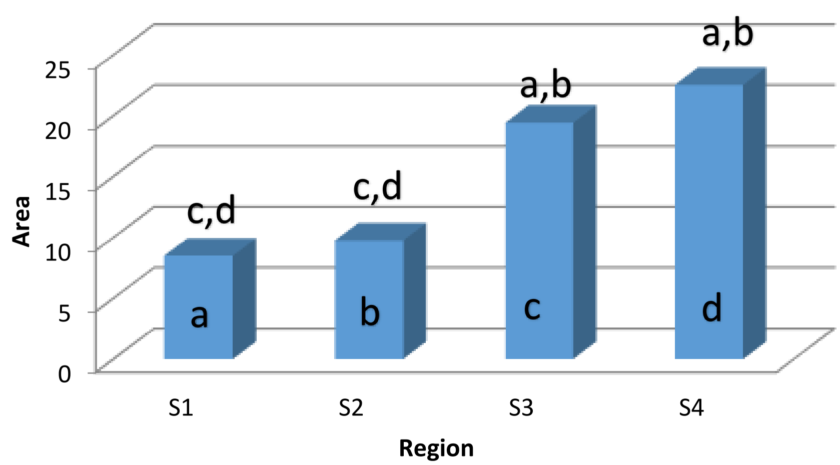

Fig 5: Leaf surface area of olive (mm^2)

***Letters above columns represents the treatments with significant difference**

Chlorophyll content:

Samples adjacent to the eastern site of the quarry (marked S1) showed the maximum reduction in chlorophyll content of about 67% compared with the control which is collected from trees located far away from the quarry. S1 field revealed significant statistical difference with S4 one (Fig. 6).

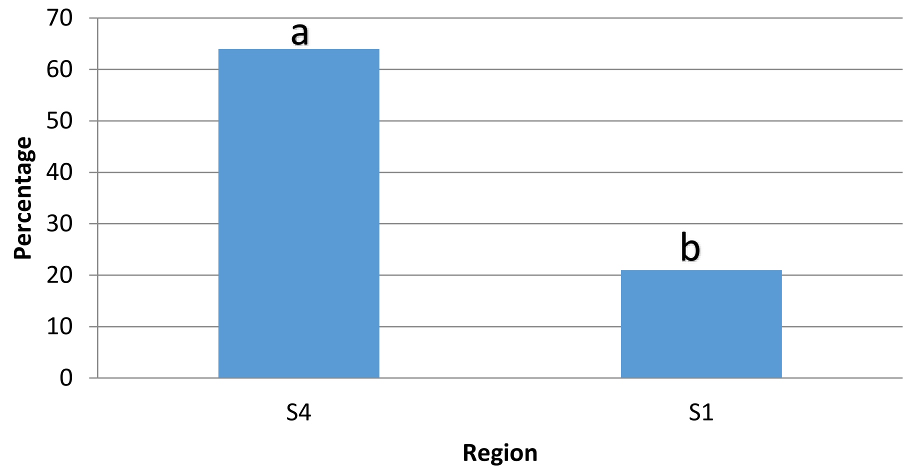

Fig 6: Total chlorophyll content of olive leaves

***Similar letters means no significant difference**

Germination experiment of olive seeds:

In case of the effect of dust on olive seed germination, the results showed that 87% of seeds from the S_4 site were found mature to germinate compared with 56% germination of seeds collected from trees in S1 site. There is a significant difference between both fields displayed in the figure below (Fig. 7).

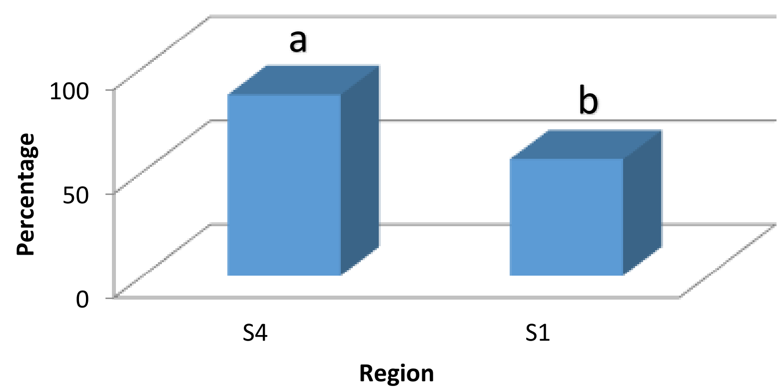

Fig 7: Olive seed germination

***Similar letters means no significant difference**

2-Effect of dust on pepper and tomato plants:

Plant yield:

The results showed that the untreated samples revealed maximum yield production compared with the dusted ones. In addition, T2 and P2 showed the highest drastic reduction of yield compared with T1 and P1 in both plants. Stastical analysis showed significant differences between treated and untreated samples for both plants. Different doses of dust on both plants was responsible for statistical significant difference between treatments (Fig. 8 and 9).

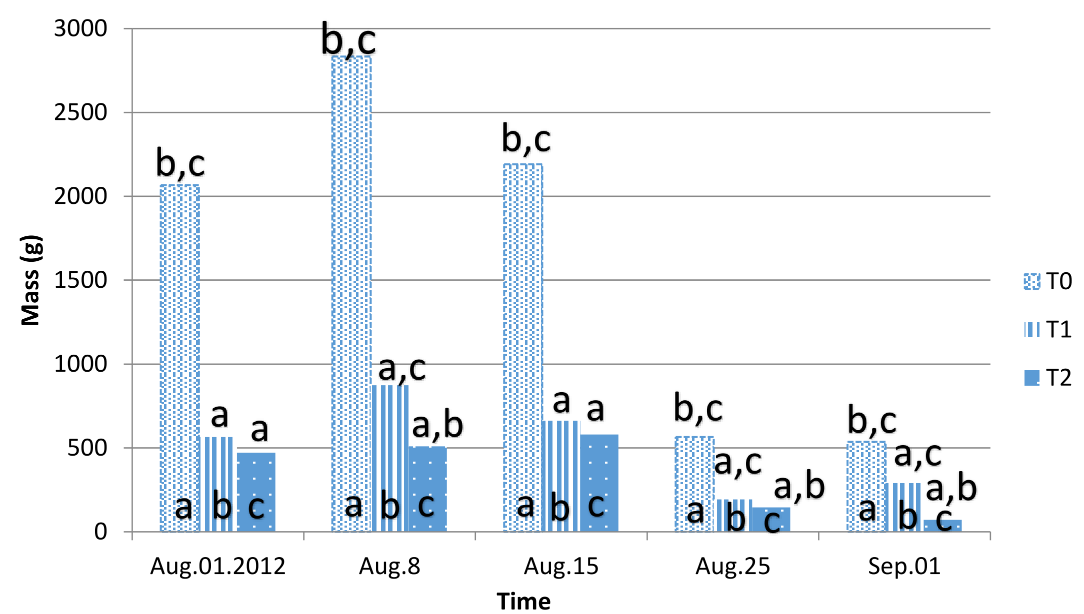

Fig 8: Effect of dust on tomato yield

***Letters above columns represents the treatments with significant difference**

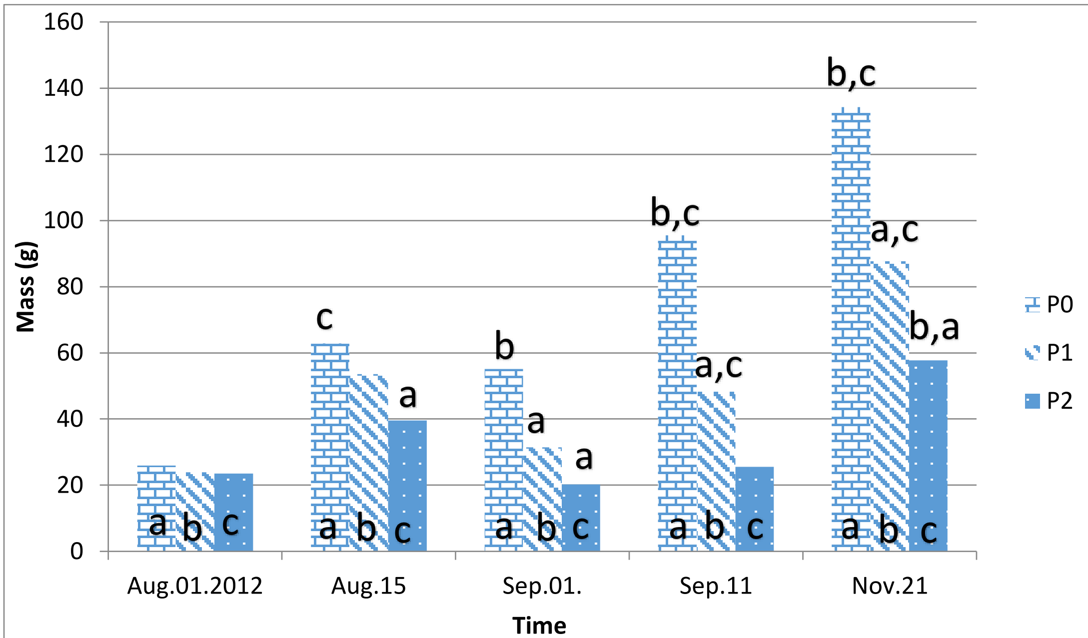

Fig 9: Effect of dust on pepper yield

***Letters above columns represents the treatments with significant difference**

Leaf surface area:

Tomato and pepper plants also revealed a reduction in the leaf surface area by increasing dust deposition. Table (2) shows a reduction in leaf surface area with respect to the control. P2 and T2 were showed drastic reduction in the leaf surface area compared with P1 and T1. In addition, the results indicate that the leaf surface are of pepper was affected more than tomato. Statistical analysis revealed significant differences between the treated plants.

Table 2: Reduction % in leaf surface area compared with control

Tomato	Percentage	Pepper	Percentage
T_1	0.2%	P_1	32.5%
T_2	4.3%	P_2	42.7%

Chlorophyll content of pepper:

Also, chlorophyll analysis carried out on pepper samples revealed a reduction in chlorophyll a, b and total chlorophyll. Total chlorophyll contents of pepper were 3.84 and 11.34 when the amounts of dust were 0.543g and 1.754g/50 cm^2 respectively. The total chlorophyll content of the control sample was 17.49. Statistical analysis showed significant differences between the total chlorophyll content of the P2 compared with P1 and P0 treatments (Fig. 10).

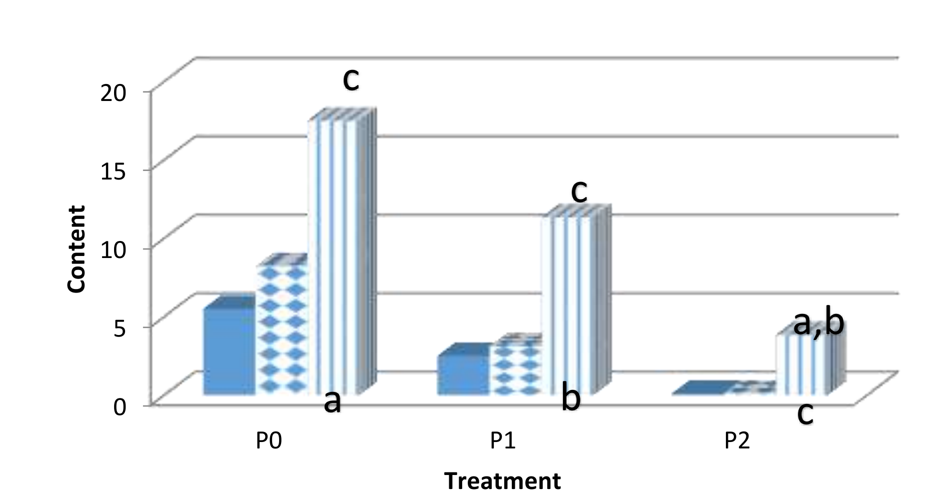

Fig 10: Cholorophyll content of pepper

***Letters above columns represents the treatments with significant difference**

Flowering percentage of pepper:

Dusted pepper cultivars also showed a reduction in the number of flowers as the concentration of dust increased. Figure 11 shows the percentage of flowering of pepper plants ranged from 62% for P_2 to 80% for P_1 compared with the control which was 98%. Statistical analysis showed significant differences between all treatments (Fig. 11).

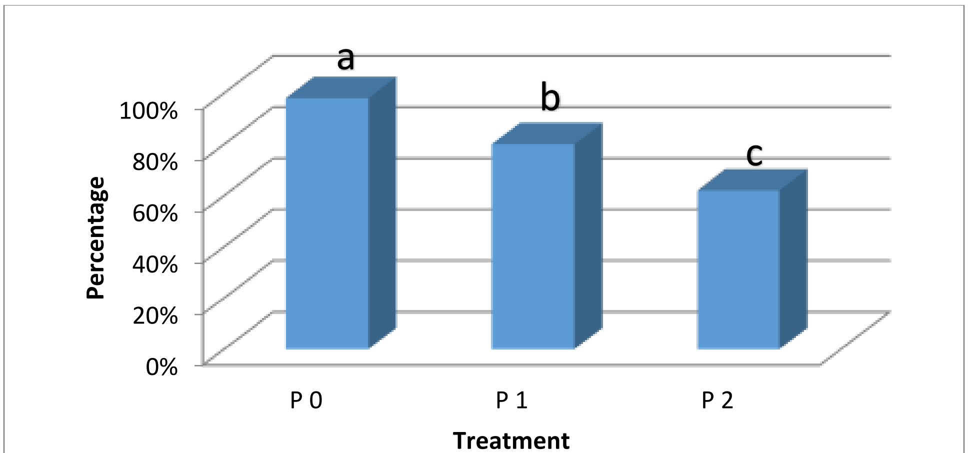

Fig 11: Percentage of pepper flowering

***Similar letters means no significant difference**

Discussion:

Dust is important in its impact on plant including vegetables and olive trees. Dust falling onto plants may physically smother the leaves and affect plants negatively. The level of deposition is important. This is affected by dust emission rate, field location and the distance from the quarries. Therefore, olive field adjacent to quarried were more affected with dust compared with distant ones (S4). As these field have opportunity to capture high dose of dust. In addition, the fields located east to quarry received much higher dose of dust due to wind direction which comes from west, southwest and northeast throughout the year. Western winds, followed by southwestern winds, are the prevailing winds in Palestine. In addition, northeastern winds prevail sometimes (WAFA INFO. 2011b; Badawi, 2013). In such regard, Kumar and Thambavani, (2012) reported that plants of *Polylthia longifolio* and *Ficus religiosa* were inversely affected with dust according to their distance from the cement factory in Virudhunagar/India.

Dust has negative effect on plant photosynthesis including its effect on chlorophyll content and stomata function. In this regard, the results showed that chlorophyll content has been reduced by 36% for the control region (S_4), while in S1 region revealed 79% reduction in total chlorophyll content. This shows that wind direction coupled with the distance from the quarry plays an important role on the amount of dust deposition. Kumar and Thambavani, (2012) reported that plant photosynthetic pigments were reduced in dust-exposed plant species due to deceleration of biosynthetic processes of such pigments rather than their degradation.

Dust on plant leaves blocks stomata and lowers their conductance to CO_2, simultaneously interfering with photosystem. The dust on olive leaves caused changes in the chlorophyll content. In this regard, Nanos and Ilias, (2007) reported that cement dust decreased the total chlorophyll content and chlorophyll a & b ratio of olive trees. Such reduction in chlorophyll content may be attributed to shading effect of dust and damage to photosynthetic apparatus. This reduction of light quantity, due to increased reflectance, causes reduction of photosynthetic rate and quantum yield (Nunes *et al.,* 2004).

In addition, Krajickova and Mejstrik, (1984) reported that the particle size of dust is important to affect stomatal functions. In addition, dust has both physical and chemical effect on plants. The chemical effect is either on soil or directly on the plant surface, and may be more important than physical effects. Raja *et al*., (2014) reported that dusting of 0.5 g /(m^2.day) of fly ash negatively affect photosynthesis, stomatal conductance, and transpiration of rice. A significant reduction of 20.2 % in grain yield was recorded when fly ash was dusted at 1.5 g /(m^2.day). Furthermore, the effect of dust was attributed to its ability to increase plant heat load and reduce intercellular CO2 concentration.

Decreasing in chlorophyll content might be due to chloroplast damage by incorporation of cement kiln dust into leaf tissue. The dust damages the chloroplasts by alteration of the leaf pH (Singh and Sirvastava, 2002).

Olive orchards located near the limestone quarry like S_1 revealed a reduction in their oil productivity. Farmer, (1993) reported that cement dust on plant leaves reduces productivity of evergreen trees and causes damage to the inorganic leaf content.

The reduction of seed germination of olives may be attributed to the stress conditions caused by long-term exposure to dust. Such conditions may affect the physiological activities of plants to the extent that plants produce seeds with low viability and minimum ability to germinate (Paramesha Naik, *et al.*, 2006).

Furthermore, the results emphasized the negative effect of dust on plant growth including leaf surface area as well as plant flowering and yield. Such situation may be attributed to dust accumulation on leaf surface which induces stress-like conditions, reduction of stomata conductance, photosynthesis and transpiration and increased leaf temperature. Such reasons justify the yield reduction of both olive trees and vegetables. Olive trees beside quarries are continuously exposed to dust which deposits over a short interval especially during flowering period which is considered the most critical reason for flower abortion and yield reduction. This agreed with the results of Zia-Khan *et al.*, (2015) who reported that dust reduces the yield of crops through reduction of stomatal conductance and the rise of canopy temperature.

Conclusion:

Quarry dust causes environmental pollution problems on the agro-ecosystem. Short-term exposure to dust causes important changes in leaf surface area, chlorophyll content and flowering. The present research revealed that the leaf area of pepper cultivars and olive trees is greatly reduced with increasing the dust accumulation thus decreasing exposure to light. Long-term exposure to dust causes reduction in vegetative and yield.

In Palestine where arid climates prevail, there is no regular natural removal of dust particles on the plant leaves by strong wind and rain. Future researches should focus on measures to reduce the dust deposition in the plants, and the avoidance of pollution caused by quarries, and their potential to increase the yield. Furthermore, the farmers should also be advised to relocate their farm lands to a distance away from the factory or the government should impose rules to relocate quarries to regions away from agricultural area. Also, the management of quarries should employ some pollution control devices.

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تأثير غبار الحجر الجيري كمرض لاإحيائي على الخضار والزيتون في فلسطين

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الملخص

أجريت تجربة في عام 2011 لدراسة تأثير الغبار الجيري لمقالع الحجارة (المحاجر) على المحاصيل الزراعية من الخضار وأشجار الزيتون. تمت دراسة تأثير هذا الغبار على الخضروات بما في ذلك محصولي البندورة والفلفل في الحقول المفتوحة للجامعة العربية الأمريكية في جنين (AAUP). بالإضافة إلى ذلك، تمت دراسة تأثير هذا الغبار على بساتين الزيتون القريبة من المحاجر في منطقة قباطية. تم استخدام اختبار العينة ثنائي التناسب (TSTP) كطريقة إحصائية لتحليل البيانات التي تم الحصول عليها من المناطق المدروسة. أظهرت النتائج أن تعرض النبات للغبار يسبب تأثيراً سلبياً قاسياً على مساحة سطح الورقة والإنتاجية لكل من محاصيل الخضروات وأشجار الزيتون. انخفض محتوى الكلوروفيل والنباتات المزهرة من نباتات الفلفل مع زيادة كمية الغبار. علاوة على ذلك، أوضحت النتائج أن تعرض أشجار الزيتون على المدى الطويل للغبار يقلل من إنتاجية الزيت بنسبة تصل الى 55.3–84.4٪ ويقلل من نسبة النضج في البذور ونسب الإنبات.

الكلمات المفتاحية: غبار الحجر الجيري، أشجار الزيتون، الخضار، فلسطين.