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Ecophysiological Disturbances in Cotton (*Gossypium barbadense* L.) and Tomato (*Lycopersicon esculentum* Mill.) Plants in Response to $CaCO_3$ Dust, Emitted from Asphalt-Batch Processes

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Abstract: In study area the pH of the soil under cotton and tomato plants was increased by $CaCO_3$ fall-out on the soil surface. The two species received the maximum deposition of $CaCO_3$ dust (1.09 and 1.64 mg cm^{-2} of leaf surface area respectively) at plot I (lies directly on the road). This may explain why their growth was significantly retarded at this plot as compared with plot II and III (40 and 100 m respectively away from the road). Such reduction in plant growth had resulted in a significant decrease in fruit yield, which amounted to 54, and 25% respectively relative to plot III. Chlorophyll 'a' increased in both plants with the increase in $CaCO_3$ dust whereas chlorophyll 'b' decreased and the increase in the first exceeded the decrease in the latter causing an increase in chl a/b ratio.
The percentage increase in N (62%) and K (31%) in cotton and P (79%) and K (150%) in tomato was higher in the vicinity of the road (plot I). The other elements (P, Na, Ca and Mg in cotton; N, Na, Ca and Mg in tomato) showed tendency to decrease with the increase in $CaCO_3$ dust. In this context, the low concentration of Na and high concentration of K in the two species at the same plot has lead to a decrease in Na/K ratio. Currently, the low Ca^{2+} content in two species in the vicinity of the road indicate that these plants may bind Ca^{2+} taken in water insoluble form and can maintain themselves to some extent in $CaCO_3$ polluted environment. Mg followed the same trend as that of Ca^{2+}.

Key words: $CaCO_3$ dust, cotton (*Gossypium barbadense* L.), tomato (*Lycopersicon Esculentum* Mill.), growth, yield, chlorophyll, mineral elements

Introduction

Atmospheric pollution in Egypt comes mainly from exaggerated human activities such as urbanization and industrialization. In recent years, the extensive increase in human activities has led to contaminate the food, forage, vegetable and ornamental plants with different kinds of dust such as cement dust (Pandey and Simba, 1989 &1990; Migahid and El-Darier, 1995; El-Darier and Migahid, 1999), sulfur dust (Hongfacao, 1989; Mayo *et al.*, 1992) and $CaCO_3$ dust (Migahid and Abdel-Haak, 1994). Dust has adverse effects on vegetation near roads (Hirano *et al.*, 1990). There is an increasing amount of evidence implicating $CaCO_3$ dust influence on plant growth, dry matter production and nutrient distribution and equilibrium (Abou El-Khair, 1988; El-Darier and Kasim, 1998). Several studies have also confirmed that excess $CaCO_3$ dust inhibits glycolysis, opening of stomata and antagonizes the absorption of some nutrients from the soil such as K and Mg (Zaharopoulou, 1993; Vardaka, 1995). On the other hand, while low cytoplasmic calcium favour the energy producing pathways of glycolysis and TCA cycle high cytoplasmic calcium tend to favour biosynthetic pathways, including lignin, aromatic compounds, fatty acids and nucleic acid biosynthesis (Allen and Trewavas, 1987).

Wheeler and Sale (1980) stated that field studies concerning the response of plants to pollutants are necessary since the information extracted from bench experiments is not useful in predicting the potential crop loss because of the nonlinear crop growth and yield. The vehicle motion on dry, unsurfaced landscapes creates tremendous amounts of fugitive dust as soil particles are dislodged and carried into the atmosphere through environmental actions (Parker, 1978; Cowherd *et al.*, 1990). The maintenance of highways through asphalt-batch processes includes spreading out a layer of fine $CaCO_3$ bricks followed by laying down an asphalt layer. A delay in the immediate support of the second step will certainly lead to the contamination of roadside plants with stormed $CaCO_3$ dust resulting from motor motion. The present study provides a brief description for the influence of $CaCO_3$ dust emitted from asphalt-batch processes on some growth criteria, fruit yield, chlorophyll content and element equilibrium of cotton (*Gossypium barbadense* L.) and tomato (*Lycopersicon esculentum* Mill.) plants cultivated at El-Bihera province.

Materials and Methods

The present study was carried out along a subway branched from Alexandria-Cairo agriculture highway at 50Km from Alexandria, south west of Damanhur city, El-Bihera Province (Fig. 1). The subway extends for about 35 km through a number of villages. Most of the food and crop species cultivated on both sides of this subway were subjected to $CaCO_3$ dust emitted from asphalt-batch processes over three summer months during 2000. All species were more or less affected, but cotton and tomato plants were strongly damaged and caused a considerable economic loss for local farmers.

Eight locations were selected along the subway, where at each location three plots were marked at right angles and at distances 0, 40 and 100 m from the road. At each plot ten individual plants from each species were randomly selected, covering the study area.

The total dry weight and dead vegetative and reproductive parts of the two studied species were determined. The vegetative parts were washed gently in distilled water. The water was collected in clean and weighed porcelain pots, then evaporated to determine the weight of the wasted dust as mg cm^{-2} of leaf surface area of the two species. The wasted vegetative parts were divided into two weighed lots. The first was used to determine the chlorophyll 'a' and chlorophyll 'b' content on a fresh weight basis according to Moran, (1982). The second lot was oven-dried at 65 °C, weighed and the ground material was digested with triple acid reagent HNO_3: H_2SO_4: $HClO_4$ 10:1:1 and analyzed for their contents of P, K, Na, Ca and Mg using an atomic absorption spectrophotometer. Total N was determined by Micro-Kjeldahl methods. Three soil samples were collected at each plot in

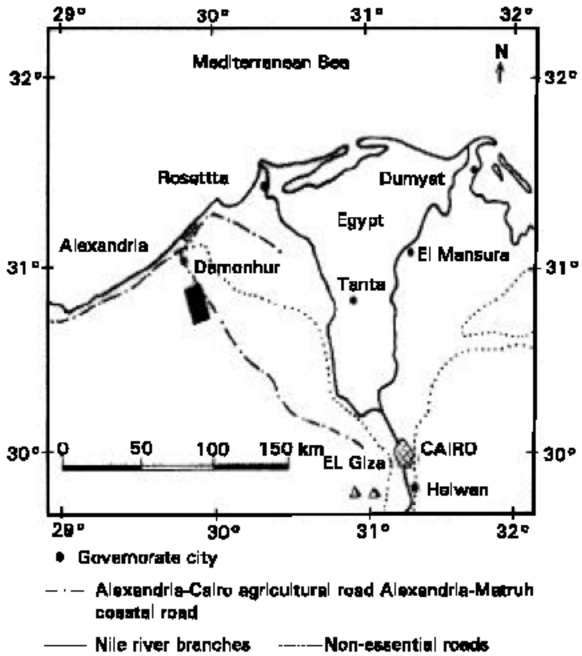

Fig. 1: Map indicating the location of the study area (black rectangle)

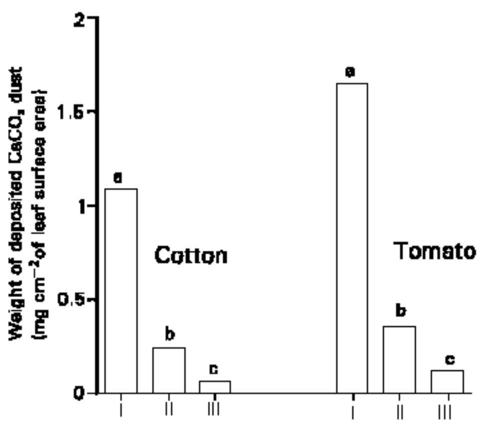

Fig. 2: Weight (mg cm^{-2} of leaf surface area) of $CaCO_3$ dust deposited on leaves of cotton and tomato plants at three different plots (I=plot lies directly on the road; II = plot lies 40 m away from the road; III = plot lies 120m away form the road). Different letters at top of each bar indicate a significant difference at 0.05 level of probability as evaluated by ANOVA test.

each location from the surface to a depth of 30 cm. These were air-dried and passed through a 2mm sieve to eliminate the gravel and debris. Soil water extracts of 1:5 were prepared and used in the determination of electrical conductivity (EC) and pH by an electrical conductivity meter LF 56 and a glass electrode pH meter. Determination of $CaCO_3$ % was carried on air-dried soil samples using a Collins

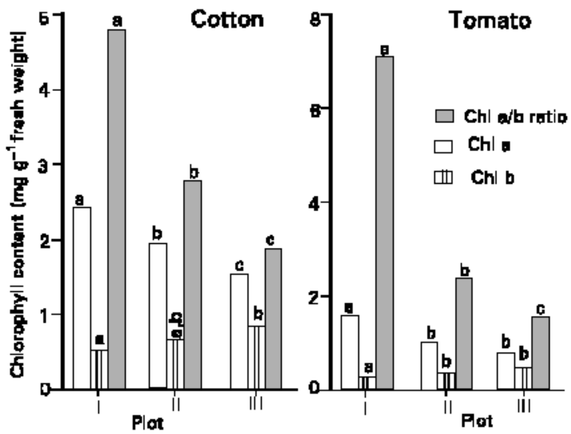

Fig. 3: Chlorophyll "a" and "b" content (mg g^{-1} fresh weight) and "a/b ratio" as influenced by $CaCO_3$ dust at three different plots (I=plot lies directly on the road; II = plot lies 40 m away from the road; III = plot lies 120m away form the road). Different letters at top of each bar indicate a significant difference at 0.05 level of probability as evaluated by ANOVA test.

calcimeter of the type described by Wright (1939). All these procedures follow Allen *et al.* (1974).

Treatment of data analyses of variance were performed using COSTAT 0.2 statistical analysis software to test the significance ($p<0.05$) of variation in different growth criteria and mineral contents of the two studied species.

Results and Discussion

Deposition of $CaCO_3$ dust on soil and leaf surfaces of cotton and tomato plants: In this work, $CaCO_3$ dust was found to cause some changes in soil characteristics (Table 1). Measurements of soil pH indicated that the soil solution under cotton and tomato plants in the vicinity of the road (plot I) was alkaline (pH = 8.7 and 7.9 respectively), while it was more or less neutral as 7.1 and 7.2 far from the road (Plot III; 100 m). $CaCO_3$% of soil under the two species was nearly twice at plot I (7.2 and 6.5% respectively) relative to plot III (2.8 and 3.3% respectively). On the other hand, the electrical conductivity (EC) was not significantly affected by the amount of deposited $CaCO_3$ dust at the three plots. Similar results have also been reviewed recently by Arslan and Boybay (1990), Migahid and El-Darier (1995) and El-Darier and Migahid (1999).

The results of present study suggest that there are spatial specific changes observed primarily on the significant ($p<0.05$) increase in amount of $CaCO_3$ dust (1.09 and 1.64 mg cm^{-2} of leaf surface area) deposited on leaf surfaces of cotton and tomato plants (tomato> cotton) respectively at plot I (Fig. 2). The amount decreased (0.247, 0.059 mg cm^{-2} of leaf surface area for cotton and 0.363, 0.136 mg cm^{-2} of leaf surface area for tomato) as the distance increases from the road at plots II and III respectively. Migahid and Abdel-Haak (1994) stated that leaves of *Asphodelus microcarpus* grown in vicinity of a quarry for limestone cuttings received higher amounts of $CaCO_3$ dust as compared with those at the control site. On the other hand, Migahid and El-Darier (1995) and El-Darier and Migahid (1999) reported that some halophytic species in salt marshes near a cement factory at El-Hammam city received much higher amounts of

Table 1: Variation in $CaCO_3$ (%), pH and electrical conductivity (EC) (mmhos/cm) of soil under cotton (*Gossypium barbadense* L.) and tomato (*Lycopersicon esculentum* Mill.) plants cultivated on both sides of a subroad branched from Alexandria-Cairo agricultural highway at El-Bihera province. (Number of locations = 8, Number of plots at each location =3).

Parameters	Cotton (*Gossypium barbadense* L.)			Tomato (*Lycopersicon esculentum* Mill.)		
	I	II	III	I	II	III
$CaCO_3$	7.2	5.4	2.8	6.5	5.2	3.3
PH	8.7	8.1	7.1	7.9	7.5	7.2
EC	12.8	13.2	11.9	15.6	14.8	15.1

I, II and III are plots within each location. I = Plot lies directly on the road
II = Plot lies at 40 m distant away from the road III = Plot lies at 100 m distant away from the road

Table 2: Effect of $CaCO_3$ dust on some growth characters of cotton (*Gossypium barbadense* L.) and tomato (*Lycopersicon esculentum* Mill.) plants cultivated on both sides of a subroad branched from Alexandria- Cairo agricultural highway at El-Bihera Province. (Number of locations = 8, Number of plots at each location =3, Number of individuals at each plot = 10).

Growth characters	Tomato (*Gossypium barbadense* L.)			Cotton (*Lycopersicon esculentum* Mill.)		
	I	II	III	I	II	III
Number of FL/Plant	40a	42a	50b	5a	15b	38c
Number of DL/Plant	30a	20b	18b	30a	28a	18b
Leaf live: dead ratio	1.33a	2.1b	2.77c	0.16a	0.53b	2.11c
Number of HF/Plant	22a	48b	71c	3a	9b	33c
Number of DF/Plant	56a	32b	11c	39a	29b	5c
Fruit live: dead ratio	0.39a	1.5b	6.45c	0.077a	0.31b	6.60c
Total shoot dry weight (g $plant^{-1}$)	85a	115b	165c	50a	88b	1.30c
Fruit yield (ton/fed.)	6a	7.8a	11b	1.5a	3.60b	6c

Different letters indicate a significant difference at $p < 0.05$ as evaluated by one-way ANOVA.
FL= Foliage leaves DL= Dead leaves HF= Healthy fruits DF= Dead fruits
I = Plot lies directly on the road II = Plot lies at 40 m distant away from the road
III = Plot lies at 100 m distant away from the road

Table 3: Effect of $CaCO_3$ dust on the concentration (mg g^{-1}dry wt.) of some mineral elements and pH of the plant extract in cotton (*Gossypium barbadense* L.) and tomato (*Lycopersicon esculentum* Mill.) plants cultivated on both sides of a subroad branched from Alexandria-Cairo agricultural highway at El-Bihera Province. (Number of locations = 8, Number of plots at each location =3, Number of individuals at each plot = 10).

Growth characters	Cotton (*Gossypium barbadense* L.)			Tomato (*Lycopersicon esculentum* Mill.)		
	I	II	III	I	II	III
N	18.15a	12.75b	11.12b	5.85a	6.75b	14.15
P	1.18a	1.50b	1.90c	0.75a	0.55b	0.42
K	21.00a	20.00a	16.00b	15.00a	9.70b	6.00
Na	1.30a	1.90b	4.40c	1.80a	3.70b	5.30
Ca	20.00a	28.00b	34.00c	36.00a	40.00a	74.00
Mg	4.80a	6.00b	8.40c	2.40a	6.00b	12.00
PH of the plant extract	6.0a	6.1a	6.4a	7.4a	7.2a	7.4

Different letters indicate a significant difference at $p < 0.05$ as evaluated by one-way ANOVA.
I = Plot lies directly on the road II = Plot lies at 40 m distant away from the road
III = Plot lies at 100 m distant away from the road

deposited cement dust in the site near the factory relative to the sites far from the factory (5.0, 1.7 and 1.0 $\mu g\ cm^{-2}$ of branch surface area respectively). The difference in the amount of $CaCO_3$ loaded on the leaf surfaces of the studied species (tomato > cotton) in present study may be due to the effectiveness of the morphological and anatomical peculiarities of the leaf. Tomato leaves have a thin outer cuticle covered by two types of trichomes; multicellular hair and glandular trichomes. The latter type is responsible for secreting a yellow sticky substance that gives off the characteristic "tomato plant" smell and catch air-borne dust and fine materials (Rost, 1996). Cotton leaves are relatively rigid, have a thick smooth cuticle and more supporting tissues than tomato.

Effect of $CaCO_3$ dust on growth and chlorophyll content of cotton and tomato plants: The maximum deposition of $CaCO_3$ dust on plant leaf surfaces at plot I may explain why the growth of the two studied species was significantly ($p < 0.05$) retarded as compared to other plots (II and III). The total shoot dry weight (g/plant) of the two plants significantly reduced to about 50% near the road in comparison with plot III. Nevertheless, records of the number of living and dead leaves and fruits, live: dead ratio and fruit yield of cotton and tomato (Table 2) indicated a large increase in dead parts (tomato > cotton) in response to the increase in $CaCO_3$ dust near the road (leaf live: dead ratio = 1.33 and 0.16; fruit live: dead ratio = 0.39 and 0.077 respectively) compared to plot III (leaf live: dead ratio = 2.77 and 2.10; fruit live: dead ratio = 6.45 and 6.60 respectively). Freer-Smith *et al.* (1997) reviewed that the effect of environmental dust may be physiological by accelerating the rate of leaf senescence or physical, by blocking stomatal aperture, thereby reducing the ease of gas exchange and photosynthetic capacity of the plant. Migahid and Abdel-Haak (1994) confirmed this idea and attributed the decrease in growth of *Asphodelus microcarpus* to the inhibition of stomatal opening caused by accumulation of limestone dust on the shoot. In present study the increase in the percentage of dead leaves of cotton and tomato plants (43 and 86% of the total leaves respectively) near the road had resulted in a great reduction in fruit yield (54 and 25% relative to plot III respectively).

These findings confirmed the results of Sai *et al.* (1987). Field observations showed that cotton plant carries a great number of capsules which become dry and are rapidly dropped which means that $CaCO_3$ dust affect the rate of capsule senescence. Moreover, tomato exhibited a deformed shape of berry (too small, thin and long), which may be due to the physiological effect of $CaCO_3$ dust on the growth and the elastic properties of cell wall (Mayo *et al.*, 1992). A covering of dust on leaf surfaces increases leaf temperature (Hirano *et al.*, 1995) and water loss (Fluckinger *et al.*, 1979), while decreasing carbon dioxide uptake (Hirano *et al.*, 1995). Moreover, Larcher (1998) stated that with high leaf temperature the rate of photosynthesis falls off sharply, and at the same time the intensified rate of respiration frees large amounts of CO_2. These physiological changes suggested that vegetation and cultivated crops around unsurfaced roads are susceptible to chronic decreases in photosynthesis and growth which may eventually lead to an economic loss and accelerated the erosion problems from the damage of cultivated crops and the lack of adequate roadside vegetative stabilization.

As far as the effect of $CaCO_3$ dust on photosynthetic pigments of cotton and tomato plants is concerned, the present data indicated that while chlorophyll 'a' increased in both plants with the increase in $CaCO_3$ dust, chlorophyll 'b' decreased and the increase in the first exceeds the decrease in the latter causing an increase in chl a/b ratio (Fig. 3). The increase in chl 'a' in plot I was 60 and 106% while the decrease in chl 'b' amounted to 38 and 54% in the two species respectively in comparison with plot III which indicate the sensitivity of chl 'b' to $CaCO_3$ dust. Our results are consistent with those of Migahid and Abdel-Haak (1994) with regard to $CaCO_3$ dust and in contradiction with those found by Pandey and Simba (1990), Prasad and Inamdar (1990), Migahid and El-Darier (1995), and El-Darier and Migahid (1999) about the effect of cement dust on some wild and cultivated plant species. The two chloroplast enzymes, fructose-1, 6-bisphosphatase and sedoheptulose-1, 7-bisphosphatase are highly sensitive to calcium in which catalytic activity following activation is inhibited by excess calcium which means that the chloroplastic isozymes may be regulated by cytoplasmic calcium (Allen and Trewavas, 1987). At this context, it is interesting to mention that chl 'a' is much more tolerant to $CaCO_3$ dust than 'b' which is more sensitive for both types of pollutants (cement & $CaCO_3$) and the reduction in plant growth might not be attributed to pigment content. The deficiency in some chlorophyll fractions sometimes occurs when the mineral balance in leaves has been disturbed. Nevertheless, the deposition of $CaCO_3$ dust on leaf surface may cause breakdown of some chlorophyll fractions (Larcher, 1998). The suppression in the two chlorophyll fractions of *Picea abies* in response to ozone fumigation is supported by data provided by Robinson (1991).

Effect of $CaCO_3$ dust on nutrient equilibrium in cotton and tomato plants: The results listed in Table 3 indicate that the concentration (mg/g dry weight) of some mineral elements in shoots of the studied plants at plot I achieved high increase percentages relative to plot III in N (62%) and K (31%) in cotton and P (79%) and K (150%) in tomato plants. The other elements (P, Na, Ca and Mg in cotton; N, Na, Ca and Mg in tomato) showed tendency to decrease with the increase in $CaCO_3$ dust. The comparable low concentration of Na and high concentration of K in two species at plot I resulted in a decrease in Na/K ratio; a phenomenon previously proved by Jacobson *et al.* (1960) and Nimbalkar and Joshi (1975). The relatively low Ca^{2+} content in the two species under high $CaCO_3$ dust and no increase in the pH of plant extract (Table 3) indicates that these plants may bind the excess Ca^{2+} taken in water insoluble form (as oxalates, phosphates, citrates, or tannins) or is bound within intraorganellar membranes (Allen and Trewavas, 1987) and keep cell sap at nearly constant pH. By this way these plants can maintain themselves in $CaCO_3$ polluted areas only if their acid metabolism permit sufficient amount of oxalate to be removed by circulation; a characteristic of Ca-avoiding plants. (Mengle and Kirkby, 1987; Larcher, 1975). Moreover, Levitt (1980) has previously reported that uptake of Ca^{2+} did not increase with the increase in Ca^{2+} concentration in soil which was also proved in present study (Table 1). Mg followed the same trend as that of Ca^{2+}, which was also described by Islam *et al.* (1987) and Migahid and Abdel-Haak (1994). In conclusion, we can report that $CaCO_3$ dust affects the two studied species in many aspects. It causes severe reduction in shoot growth and fruit yield an increase in chl 'a/b' ratio and a disturbance in nutrient equilibrium. Despite these effects, the two species seem to have internal mechanisms to maintain and avoid the high concentrations of $CaCO_3$ dust in their environments.

References

Abou El-Khair, K.S., 1988. Effect of calcium carbonate on the growth and mineral content of *Eucalyptus camaledulensis* DEHN. Seedlings. Alex. J. Agric. Res., 33: 345-356.

Allen, E.F. and A.J. Trewavas, 1987. The biochemistry of Plants. A comprehensive treatise. Vol (12) P. K. Stumpf and E.F. Conn. Academic Press, Inc., Sand Diego, New York, U.S.A., XIV, pp: 350.

Allen, S., H.M. Grimshay, J.A. Parkinson and C. Quarmby, 1974. Chemical analysis of ecological materials. Blackwell Scientific Publications, Osney, Oxford, London, pp: 565.

Arslan, M. and M. Boybay, 1990. A study on the characterization of dust falls. Atmospheric Env., 24 A: 2667-2671.

Cowherd, C., P. Englehart, G.E. Muleski, J.S. Kinsey and K.D. Rosbury, 1990. Control of Fugitive and Hazardous Dusts. Noyes Data Corporation.

El-Darier, S. and W. Kasim, 1998. Effect of adding calcium carbonate on growth and nutrient accumulation of *Eucalyptus rostrata* in Saudi Arabia. Desert Inst. Bull. Egypt, 48: 209-226.

El-Darier, S.M. and M.M. Migahid, 1999. Ecophysiological disturbances in two halophytic species in response to cement dust pollution. 4th National Conference for Environmental Studies and Research -Ain Shams University "Egyptian Desert Environmental Development" pp: 127-140.

Fluckinger, W., J.J. Oertli and H. Fluckinger, 1979. Relationship between stomatal diffusive resistance and various applied particle sizes on leaf surface. Z. Pl. Physiol., 9: 173-175.

Freer-Smith, P.H., S. Holloway and A. Goodman, 1997. The effect of dust on vegetation- a review, Env. Pollut., 79: 63-75.

Hirano, T., M. Kiyota, Y. Kitaya and I. Aiga, 1990. The physical effects of dust on photosynthetic rate of plant leave. J. Agric. Meter, 46: 1-7.

Hirano, T., M. Kiyota and I. Aiga, 1995. Physical effects of dust on leaf physiology of cucumber and kidney bean plants. Env. Pollut., 3: 255-261.

Hongfacao, T., 1989. Air pollution and its effects on plants in China. J. Appl. Ecol., 26: 763-773.

Islam, A.K., C.J. Asher and D.G. Edwards, 1987. Response of plants to calcium concentration in following solution culture with chloride or sulfate as a counter ion. Plant and Soil, 98: 377-385.

Jacobson, L., D.P. Moore and R.J. Hannapel, 1960. Role of calcium in absorption of monovalent cations. Pl. Physiol., 35: 352-358.

Larcher, W., 1975. Physiological Plant Ecology. Springer-Verlag, Berlin, Heidelberg, New York, pp: 252.

Larcher, W., 1998. Physiological Plant Ecology. Third Edition, Springer-Verlag, Berlin, Heidelberg, New York, pp: 506.

Levitt, J., 1980. Responses of Plants to Environmental Stresses. Vol. (II) water, radiation, and other stresses. Academic Press, London, pp: 607.

Mayo, J.M., A.H. Legge, E.C. Yeung, S.V. Krupa and J.C. Bogner, 1992. The effects of sulfur gas and elemental sulfur dust deposition on *Pinus contorta* and *Pinus banksiana*: cell walls and water relations. Env. Pollut., 76: 43-50.

Mengle, K. and E.A. Kirkby, 1987. Principles of Plant Nutrition. International Potash Institute, P.O. Box, CH-3048 Worblaufen Bern, Switzerland, pp: 687.

Migahid, M.M. and S.M. El-Darier, 1995. Effect of cement dust on three halophytic species of the Mediterranean salt marshes in Egypt. J. Arid Env., 30: 361-366.

Migahid, M.M. and M.A. Abdel-Haak, 1994. Effect of limestone cutting dust on the leaves of *Asphodelus microcarpus* at the western Mediterranean coast of Egypt. Alex. J. Agric. Res., 39: 413-427.

Moran, R., 1982. Formulae for determination of chlorophyllous pigments extracted with N,N-dimethylformamide. Pl. Physiol., 69:1376-1381.

Nimbalkar, J.D. and G.V. Joshi, 1975. Effect of increasing salinity on germination, growth and mineral metabolism of sugar cane cv. CO-740. J. Biol. Sci., 18: 55-63.

Pandey, D.D. and A.K. Simba, 1989. Effect of cement dust on chlorophyll in gram (*Cicer arietinum*) leaves. Ind. J. Ecol., 16: 178-179.

Pandey, D.D. and A.K. Simba, 1990. Effect of cement kiln dust on chlorophyll in wheat leaf. Env. Ecol., 8: 461-463.

Parker, A., 1978. Industrial Pollution Handbook. Mc Graw-Hill Book Company Limited. England, pp: 658.

Prasad, M.S.V. and J.A. Inamdar, 1990. Effect of cement kiln dust pollution on black gram (*Vigna mungo* L.). Proceedings of Indian Academy of Science, 100: 435-443.

Robinson, D.C., 1991. Seasonal changes in the pigments of norway spruce; *Picea abies* (L.) Karst, and the influence of summer ozone exposure. New Phytol., 119: 251-259.

Rost, T.L., 1996.Tomato leaf anatomy. Section of Plant Biology, Division of Biological Sciences, University of California. USA.

Sai, V.S., M.P. Mishra and G.P. Mishra, 1987. Effect of cement dust pollution on trees and agricultural crops. Asi. Env., 9: 11-14.

Vardaka, E., 1995. Effect of dust from a limestone quarry on the photosynthesis of *Quercus coccifera*, an evergreen schlerophyllous shrub. Bull. Env. Contam. Toxicol., 54: 414-424.

Wheeler, J.L. and M.J. Sale, 1980. TELOC: A simulation model of the effects of lead on corn (*Zea mays*) growth. Ecol. Modell., 11: 141-150.

Wright, C.H., 1939. Soil Analysis. 2nd ed. Murby and Co., London.

Zaharopoulou, A., 1993. Effect of dust from a limestone quarry on chlorophyll degradation of the lichen physciaadscendens (Fr.) Oliv. Bull. Env. Contam. Toxicol., 50: 852-859.