Turk J Bot
25 (2001) 19-24

Research Article

Periodical Effect of Cement Dust Pollution on the Growth of Some Plant Species

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Received: 15.04.1998
Accepted: 28.01.2000

Abstract: A significant reduction in plant cover, height and number of leaves for *Carissa carandas* L. was observed. *Azadirachta indica* (L.) A.Juss. showed no significant changes in plant cover and height with the exception of number of leaves. *A. indica* showed a significant ($p<0.001$) reduction in number of leaves on the fourth week of observation. A pronounced effect weeks was also found for *Delonix regia* (Bojer) Raf. at $p<0.01$ and $p<0.05$ significance levels, respectively. It was concluded that the cement dust had a significant effect on the plant growth. *A. indica* was found to be less affected by cement dust pollution, while *C. carandas* was found to be highly affected. *D. regia* was moderately affected by cement dust pollution.

The analysis of the cement dust showed that it had a high percentage of maximum water holding capacity (65.72%) with fine soil textural class. Chemically, the soil was alkaline in nature having pH 9.53 with a better percentage of $CaCO_3$ (22%), and alkaline carbonate (2.45 meq/1). The amounts of chloride and conductivity were 8.6 meq/1 and 506 µs/cm, respectively.

Key Words: Cement dust, Dust analysis, Seedling growth and Trees.

Çimento Tozu Kirliliğinin Bazı Bitki Türlerinin Büyümesi Üzerindeki Periyodik Etkisi

Özet: *Carissa carandas* L.'ın bitki taç örtüsü, boyu ve yaprak sayısında önemli bir azalmaz gözlendi. *Azadirachta indica* (L.) A.Juss.'da, yaprak sayısı dışında bitki taç örtüsü ve boyunda önemli değişiklik görülmedi. *A. indica*, dördüncü gözlem haftasında yaprak sayısında önemli (p 0,001) azalma gösterdi. Dördüncü ve beşinci haftada *Delonix regia* (Bojer) Raf.'da da yaprak sayısında ve boyunda, sırasıyla p 0.01 ve p 0.05 önem seviyesinde belirgin bir etki bulundu. Çimento tozunun bitki büyümesi üzerinde önemli etki gösterdiği sonucuna varıldı. *A. indica* çimento tozu kirliliğinden az etkilenirken, *C. carandas*'ın oldukça fazla etkilendiği bulundu. *D. regia*, çimento tozu kirliliğinden orta şiddette etkilendi.

Çimento tozunun analizi, küçük tekstürlü toprak sınıfına girmesi nedeniyle, tozların su tutma kapasitesi oranının yüksek olduğunu gösterdi. Kimyasal olarak, $CaCO_3$ (%22) ve alkalin karbonat (2,45 meq/l) yüzdesi yüksek olduğundan, toprak 9.53 pH ile alkalin özellik gösterdi. Klor miktarı ve iletkenlik sırasıyla, 8.6 meq/l ve 506 µs/cm olarak bulundu.

Anahtar Sözcükler: Çimento tozu, Toz analizi, Fide büyümesi ve Ağaçlar.

Introduction

Air pollutants, responsible for vegetation injury and crop yield losses, are causing increased concern (Fuji, 1973). Air pollution has become a major threat to the survival of plants in the industrial areas (Gupta & Mishra, 1994). Rapid industrialization and addition of the toxic substances to the environment are responsible for altering the ecosystem (Mudd & Kozlowski, 1975; Niragau & Davidson, 1986; Clayton & Clayton, 1982). The cement industry also plays a vital role in the imbalances of the environment and produces air pollution hazards (Stern, 1976). In comparison with gaseous air pollutants, many of which are readily recognized as being the cause of injury to various types of vegetation, relatively little is known and limited studies have been carried out on the effects of cement dust pollution on the growth of plants. Reduction in the number of flowers and yield of black gram (*Vigna mungo* (L.) Hepper) was observed by Prasad & Inamdar (1990) due to cement dust pollution. Recently, Gupta & Mishra (1994), studied the toxic effect of cement dust on some plants. The effect of cement and stone dust on the stomatal clogging of *Iphonia grantioides* Boiss. leaves was found by Abdullah & Iqbal (1991). A marked reduction in the growth of poplar trees, 1 mile from a cement plant was observed after cement production was more than doubled (Lerman & Darley, 1975).

Stratmann & van Haut (1966) dusted plants with quantities of dust ranging from 1 to 48 g/m^2 per day; dust falling on the soil caused a shift in pH to the alkaline side, which was unfavorable to oats but favorable to pasture grass. Darley et al. (1966) noted that plants were stunted and had few leaves in the heavily dusted portions of an alfalfa field downwind from a cement plant in California. Brandt & Rhoades (1972) observed significant changes in structure and composition of the seedling, shrub, sapling, and tree strata when they compared dusted and non dusted forest communities in the vicinity of limestone quarries and processing plants.

Air pollution is a social disease, a disease generated primarily from the activities of man, adversely affecting his health and welfare (Gilette, 1984). Pollution stress can alter plant growth and quality and the effects are often extensive (Sagar, Gregory & Paul, 1982). We are facing the fact that in relatively recent times, the total amount and complexity of toxic pollutants in the environment are increasing day by day.

Karachi is the most industrialized and largest city in Pakistan. The city center is suffering from heavy cement dust pollution originating from the cement industry. The cement dust is the source of particulate matter deposits on the buildings and plants, producing a significant effect. Air pollution in addition to damaging plants, inhibits many enzyme systems and metabolic processes of plants (McCune, 1975).

A periodical study was carried out to study the effect of cement dust pollution on the growth of some trees.

Materials and Methods

Karachi is situated on the coast of the Arabian Sea at a latitude of 24° 48' N and longitude of 66° 55' E at an altitude of 1.5-37 m. The climate of Karachi has been characterized as subtropical maritime desert, where the minimum temperature is 10-25ºC in January and the maximum is 27-33ºC in July. There are three seasons. The hot and humid rainy season lasts from June to September. The average rainfall is 20 cm. The winter season is short from the middle of November to the middle of February. The temperature is mild with no frost. The other months constitute the summer season. The sea breeze is constant throughout the year, except during the winter months when the wind direction is reversed. Dew formation is quite common when the relative humidity is high and the differences in day and night temperatures are great. The experimental site is located at the Karachi University Campus at the Department of Botany. The experiment was conducted in pots under natural conditions. Mature ripe seeds of *Carissa carandas* L., *Azadirachta indica* (L.) A. Juss. and *Delonix regia* (Bojer) Raf. were collected. The seeds of all the three species were sown in medium sized clay pots with three parts fine sand and one part natural manure. When the seedlings reached a suitable height, they were transferred to pots, 25.0 cm in diameter and 22.0 cm in depth. One gram of cement dust was sprinkled regularly on the aerial parts of each plant twice a week, except the control. All the plants were watered daily with tap water and there were five replicates. At the end of every week, the height of plant and cover were measured with a measuring tape. The number of leaves were also counted every week. The experiments lasted six weeks. The data was statistically analyzed by ANOVA and DRMT.

The chemical and physical of the dust collected in the vicinity of the National Cement Factory in Karachi was carried out. Soil textural class was determined by the pipette methods of the U.S.D.A. (1951). Calcium carbonate was determined by a method of acid neutralization (Qadir, Qureshi & Ahmed, 1966) and chloride was determined by titration. Salinity was investigated with a Radiometer D-83 and soil pH was determined with a pH reading meter (Model Jenway PHM 6). Maximum water holding capacity of the soil was also determined.

Results

The results obtained with cement-dusted and nondusted *C. carandas, A. indica* and *D. regia* were compared (Fig. 1-3 and Table 1). In general, plants showed a decrease in plant growth due to cement dust treatment. *A. indica* showed a significant ($p<0.001$) reduction in number of leaves on the fourth week of observation. The plant height was significantly ($p<0.001$) decreased in *A. indica* but plant cover remained unchanged. A highly significant ($p<0.001$) reduction in plant height, cover and number of leaves was found for *C. carandas* on the second, third and fourth weeks of observation, respecitvely (Fig. 2). There was no significant change in plant cover for *D. regia*. However, it showed a significant reduction in number of leaves ($p<0.01$) and plant height ($p<0.05$) on the fourth and fifth weeks observation (Fig. 3).

The dust collected from the vicinity of the National Cement Factory showed a high percentage of maximum water holding capacity (65.72%) and fine texture particles. The chemical composition of the soil was alkaline in nature having pH 9.5 with a better percentage of calcium carbonate (22%) and alkaline carbonate (2.45 meq/1). The chloride and conductivity were 8.6 meq/1 and 506 µs/cm, respectively (Table 2).

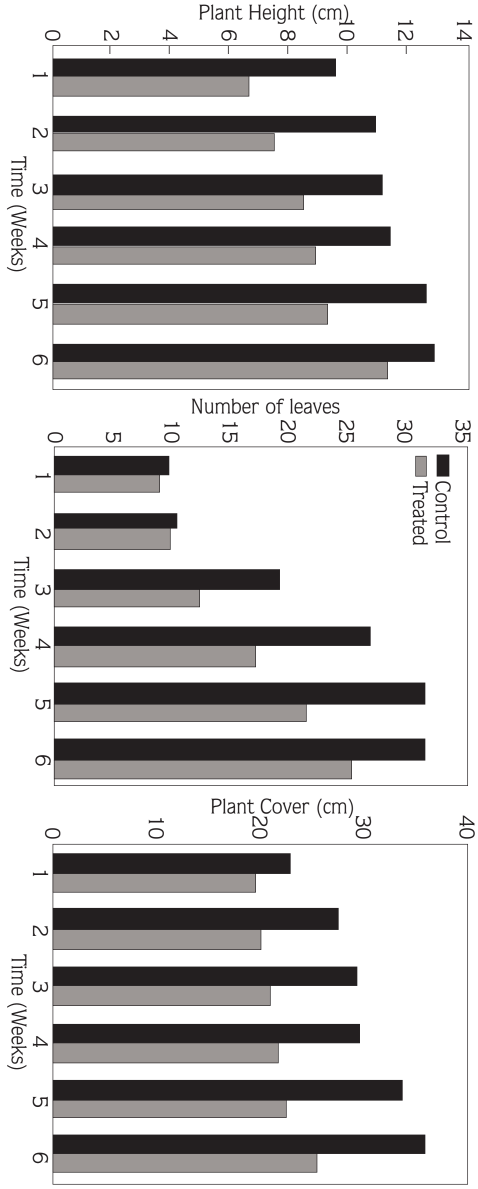

Figure 1. Effect of cement dust on the growth of *Azadirachta indica.*

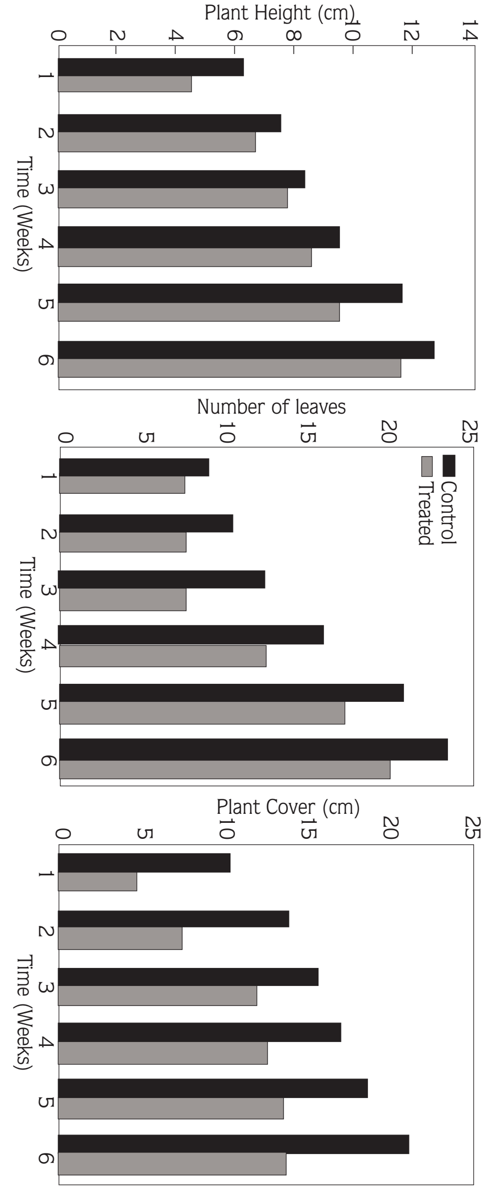

Figure 2. Effect of cement dust on the growth of *Carissa carandas.*

Table 1. Significance level LSD (0.05)

	Plant Species		
Variables	*A. indica*	*C. carandas*	*D. regia*
Plant height (cm)	3.84	2.02	4.60
Number of leaves	4.46	5.45	13.15
Plant cover (cm)	2.51	3.06	14.58

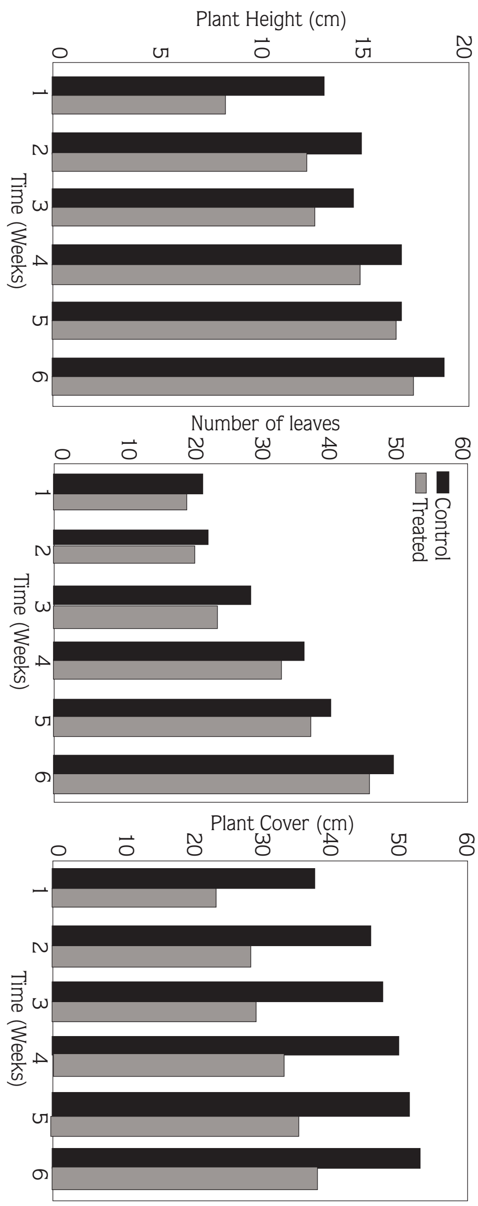

Figure 3. Effect of cement dust on the growth of *Delonix regia*.

Table 2. Analysis of dust collected around the National Cement Factory.

MWHC	65.72%
Soil pH	9.53
Soil texture	Clay loam
Calcium carbonate	22%
Alkaline carbonate	2.45 meq/1
Amount of chloride	8.6 meq/1
Conductivity	506 µs/cm
Symbol used:	
MWHC	Maximum water holding capacity
meq/1	Milliequivalent/liter

Discussion

Cement dust had a significant effect on the growth of some plant species compared with noncement dusted plants. Toxic compounds such as fluoride, magnesium, lead, zinc, copper, beryllium, sulfuric acid and hydrochloric acid were found to be emitted by cement manufacturing plants (Andrej, 1987). Reduction in plant height, cover and number of leaves of *C. carandas* showed that the losses are generally attributed to the cement dust which contained toxic metals. The results obtained are in close conformity with those reported by Stratmann & Van Haut (1966), who dusted plants with dust ranging from 1 to 48 g/m2 day -1 and concluded that dust falling on the soil caused a shift in pH to the alkaline side, which was unfavorable to oats but favorable to pasture grass. Decreased plant height of *D. regia* might be due to the decrease in phytomass, net primary production and chlorophyll content in response to the cement dusts, confirming the findings of Prasad & Inamdar (1990) in *Vigna mungo* (Black gram). The cement dust kiln showed a reduction in chlorophyll content, protein, starch, yield and phytomass in ground nuts (*Arachis hypogaea* L.) (Prasad & Inamdar, 1990). A significant reduction in leaf number for *C. carandas, A. indica* and *D. regia* agrees with the findings of Anda (1986).

Plant response varies between species of a given genus and between varieties within a given species. Plants do not necessarily show similar susceptibility to different pollutants. Major variations in response to different species to air pollutants have been documented by Jacobson & Hill (1970). Studies of biochemical changes and pollution effects on the plant metabolism, i.e., reduction in chlorophyll and completely clogged stomates (Ahmed & Qadir, 1975) reveals that these parameters are important in regulating the productivity and also the number of flowers and seeds produced.

C. carandas was found to be significantly affected in all the growth parameters. It is concluded that the presence of toxic pollutants in cement dust might be responsible for the reduction in plant growth. Traces of toxic metals such as chromium and copper are common in some varieties of portland cement and are harmful to human beings and other living systems (Omar & Jasim, 1990). The heavy metals present in the cement dust can play an important role in disturbing the various metabolic processes. The growth metabolic processes and yield of winter barley were found to be affected by the Duna cement and lime works (Borka, 1986). Greszta et al. (1988) in an experiment of six kinds of dust which contained heavy metals introduced under the stand canopy. The dust was collected from zinc, cadmium, aluminum, iron plants, electric power station and the cement plant. The dust was introduced in concentrations of 100, 500, 1000, 2000 and 5000 t Km^{-2}. The experiment proved that the cement dust brought about changes in the ecosystem. A link between the forest ecosystem under the influence of heavy metals in dust and the effect of these changes on the growth of pine stands was also obtained.

A significant reduction in plant cover of *C. carandas* compared with other species suggests that *C. carandas* is more sensitive to cement dust than the other species studied. Shafiq & Iqbal (1987) found a reduction in the number of species around the heavily polluted cement industrial units in Karachi. Darley et al. (1966) demonstrated that dust deposited on bean leaves in the presence of free moisture interfered with the rate of carbon dioxide exchange, but no measurements of starch were made.

Studies of the effects of cement-kiln dust deposited on the soils also raised questions. Some investigators reported no harmful effects of cement at levels from 1.5 to 7.5 g/m^2/day, while others reported that concentrations from 1.0 to 48 g/m^2/day caused shifts in the soil alkalinitiy which may be favorable to one crop but harmful to others (Lerman & Darley, 1975).

A quantitative estimation along with dust analysis confirms the ill effects of cement dust on the plant growth. The pH of our dust sample was basic in nature which was 9.5 and can be correlated with the findings of the Lerman & Darley (1975). In their experiment, they also found a similar range of cement dust pH (9.5-11.5). It is important to know the identity of various pollutants and their amounts to evaluate their ill effects and toxic stresses (Tinsley, 1979). The changes in the accumulation of mineral plant nutrients as a result of cement dust were also determined by Lal & Ambasht (1981). It is also suggested that complete analysis of cement dust containing all the toxic pollutants should be carried out in detail. It is hoped that, eventually, with such types of study, it would be possible to recommend plants for use as screens or green belts in industrial areas and adverse urban locations in order to mitigate dust and improve air quality (Yunas et al. 1985).

On the basis of this study, it could be concluded that growth of plants was found to be affected by cement dust, which might be due to the presence of different toxic pollutants in cement dust. The phenological behavior of *C. carandas* was found to be highly affected followed by *A. indica* and *D. regia*, respectively. It is clear that the cement dust pollution is an operative ecological factor causing a deterioration in the quality of our environment (Shah, Ilahi & Rashid, 1989). It is suggested that *D. regia* should be planted around the cement industrial units due to its resistant to cement dust toxicity.

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