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Atmospheric Dust Properties and Its Effect on Light Transmission and Crop-Soil Productivity

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Abstract

This study is to determine the effect of atmospheric dust properties on light transmittance, absorbance and crop yield. The effect of wind erosion on soil carbon and nitrogen stocks is assessed.

The plastic covers transmitted more red light than blue-violet light. Dust accumulation on cover reduces such differences but to a limit extent. The average dust accumulation rate is 4.57 x 10^{-5} mg/m^2/sec, 92.22% dust particles and 7.75% organic materials (0.299 mg/m^2/day of organic materials). Dust accumulation over a 22 week period reduced light transmittance by 60%. Crop yield was reduced by 33%.

Total soil carbon and nitrogen stocks of the upper surface are affected significantly by wind erosion. Soil carbon and nitrogen are at critically low levels because of the wind erosion. Carbon sequestration is needed to improve soil carbon and nitrogen levels.

Introduction

Atmospheric dust is a characteristic of arid regions due to the presence of dust supply and the instability in atmosphere. The life of dust storms ranges from one to several hours. The nature of dust storm varies widely from area which depends on the meteorology, topography and soil type. Atmospheric dust accumulation is considered as problem in world arid and semi-arid regions. Five major regions where dust originated: Sahara, Southern coast of the Mediterranean sea, North East Sudan, Arabian peninsula, Lower Volga and North Cocas In Russia. In the Middle-East, the ambient air considered to be highly dusty.

The single major cause of atmospheric pollution is the natural occurring dust storms, other causes of dust originates from open deserts, cleared land sands, cement, phosphate industrial activities and other such as traffic activities.

Idse, 1971, Hugazi, 2001 pointed out that the airborne dust is one of the most damaging environmental elements for greenhouse projects. A dust laden atmosphere may contribute to the deterioration of plastic materials and can present a problem in the operation and maintenance.
In the past, many attempts have been made to evaluate the performance of greenhouse in transmitting light, Bownan, 1970, Bot, 1983; Gritten, 1984; Hasson, 1993; Hasson, 1990 Most studies were aimed at calculating transmissivity which is defined as the ratio of the greenhouse floor irradiance to the corresponding outside irradiance.

Total daily PAR to the inside the cultivated 180microns thick plastic tunnel were equal. The transmissivity coefficient is a function of the greenhouse dimensions, the number of span, the type of sky radiance and the atmospheric dust accumulation. A simple model of the single scattering properties of the atmospheric Martian dust suitable for irradiative transfer calculations in the infrared was studied by Hogan, 2006.

Soils in dry lands are prone to degradation and desertification, which lead to dramatic reductions in the soil organic carbon pool. A good overview of the extent of land degradation in different dry land regions of the world is given in Dregne (2002). However, there are also some aspects of dry land soils that work in favour of CS in arid regions. Dry soils are less likely to lose C than wet soils (Glenn *et al*., 1992) as lack of water limits soil mineralization and therefore the flux of C to the atmosphere. Consequently, the residence time of C in dry lands soils is long, sometimes even longer than in forest soils. The issue of permanence of C sequestered is an important one in the formulation of carbon sequestration projects. Although the rate at which carbon can be sequestered in these regions is low, it may be cost-effective, particularly taking into account all the side-benefits resulting for soil improvement and restoration.

The objective of this study is to determine the potential of atmospheric dust accumulation and its effect on total carbon and total nitrogen crop production is studied.

The Experiment site

The experiment is carried out in the greenhouse commercial farms (Latitudes, 36. 40 S and Longitude 31 41 E) within arid and semi-arid climatologically zone. The greenhouse farm is surrounded by 200 ha covered with nearly one third of variety of grasses. Air temperature varied between the average 10 to maximum average 18C. Data were collected during the winter growing season.

The study is carried in semi-cylindrical tunnel type single- covered greenhouse 18 x 10 x 3 m^3 in size, with their long axis aligned in the east-west direction. The greenhouse is covered with 180 microns, UV stabilizer film which actively diffuses radiation. The greenhouse soil is clay loam and planted with five week-old capsicum plants, *Capsicum annum* L. in eight rows, 80cm spacing between the rows.

Experimental Measurements

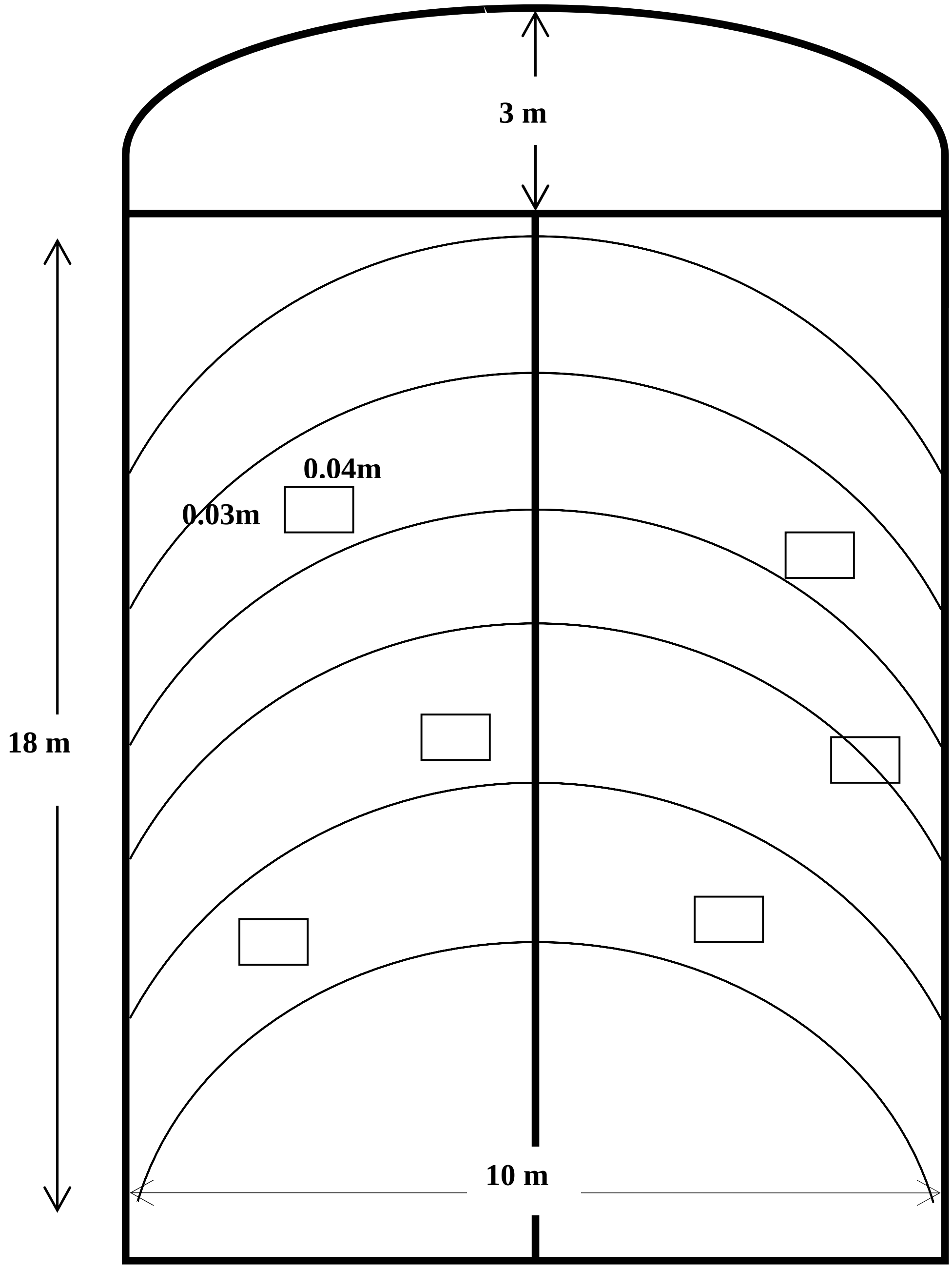
Six randomized samples, (3 x 4 $cm^{2)}$ from the dusty and undusted plastic covers were carefully cut for 52 weeks at 2 weeks intervals. Undusted samples were washed with distilled water and dried to measure the plastic degradation with no dust accumulation (Fig.1). Transmitted and absorbed light were immediately measured using Parking-Elmer, Lambda spectroradiometer 9/Vis/in 0.35 – 0.75 microns wavelength range.

The number of size distribution of the dust particles (dust density) on the plastic covers were measured using Laser Optical Photometer, LOP. A day in each month of the year was selected for the dust density measurements. Twenty four readings were taken for each selected day corresponding to one hour intervals. The average of the dust particle density (Fig. 2) is then calculated on hourly bases.

Soil samples (30 replicates) were collected in January 6, April 22, July 15, September 11 and December 22 from 200 ha paddock (1594m dia) at 0-3, 3-6, 6-10 and 10 – 30cm depths. Each soil sub-sample was collected in polyethylene bags, sealed, and delivered to the soil analysis laboratory for measurement of total nitrogen and carbon.

For total carbon determination in the soil samples using concentrated sulfuric acid is added to soil wetted with dichromate solution (Walkley and Black 1934).
Soil samples are combusted using a Leco FP-428 Nitrogen Analyzer for total nitrogen, (Sweeney, and Rexroad 1987).

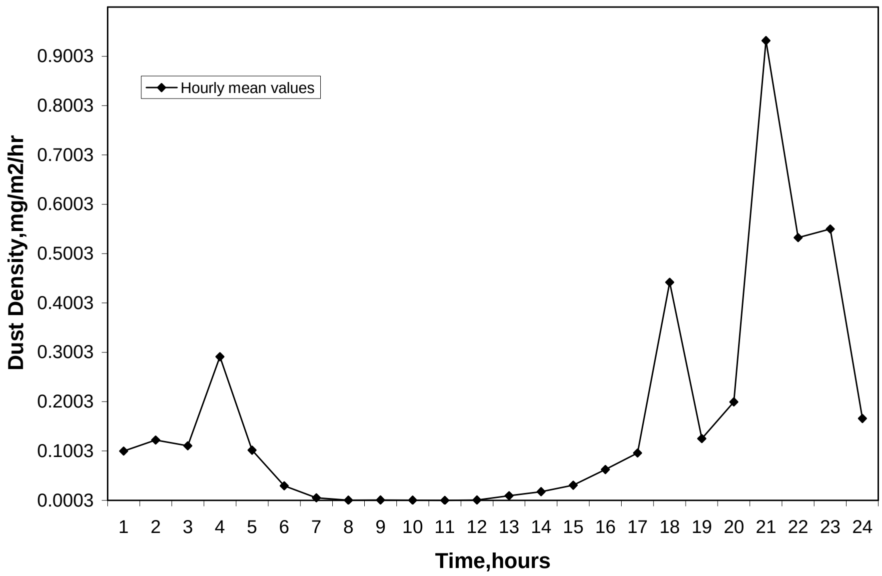
Fig.1.The experimental design and accumulated dust sampling positions diagram.



Accumulated Dust Properties

The atmospheric dust deposit on the plastic covers at the end of the growing season composed of 92.22% dust particles (inorganic materials) and 7.75% organic materials (Organic carbon) using Laser Optical Photometer, LOP. The size distribution (Fig. 2) shows that 85.45% of the dust particle diameter ranged between 0.4 – 0.9 microns, 14.47% between 1.0 – 2.0 microns and 0.08% were larger than 2.0 microns. The order of the size distribution of the dust

Fig. 2. Dust partical Density distribution



particles is 0.6 – 0.7 microns > 0.7 – 0.2 microns, 0.5 – 0.6 microns > 0.8 – 0.9 microns > 1.1 – 1.2 microns > 2.0 microns.

Table 1**.** Shows that the average dust accumulation per day is 3.597 mg/m2 which corresponded to the accumulation rate of 4.57×10^{-5} $mg/m^2/sec$. However as it appears from Fig. 2 the dust did not accumulate evenly through out the 12 weeks period as mediated by the uneven reduction in light transmittance over successive time intervals (2 weeks). Such as uneven accumulation is presumably due to changes in weather parameters during the experiment.

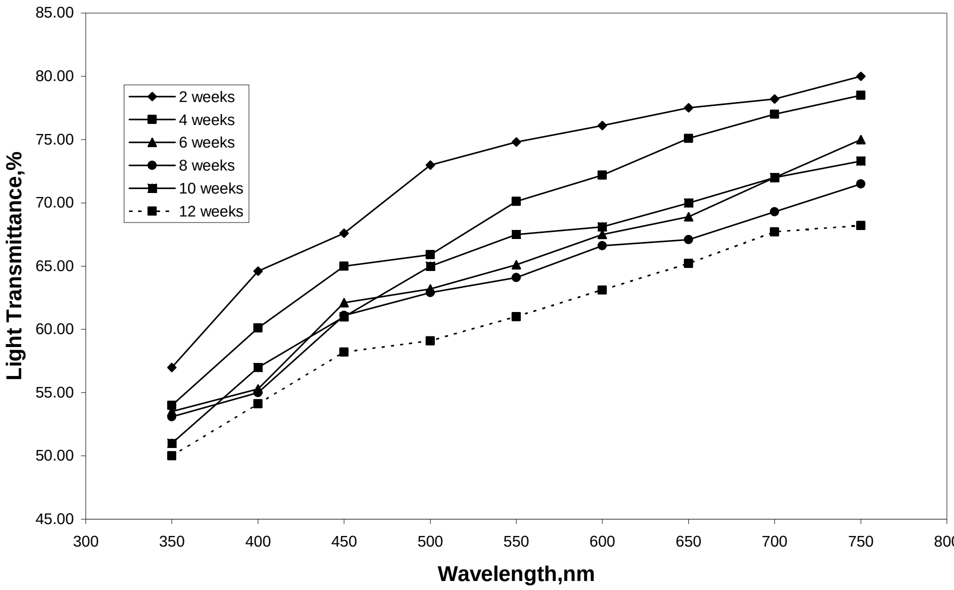
Table 1. Average dust accumulation per day.

Time, hours	Particles Density, mg/m^2
1	0.1001
2	0.1223
3	0.1108
4	0.2915
5	0.1021
6	0.0299
7	0.0096
8	0.0008
9	0.0009
10	0.0008
11	0.0004
12	0.0010
13	0.0098
14	0.0179
15	0.0311
16	0.0627
17	0.9640
18	0.4421
19	0.1253
20	0.1997
21	0.9321
22	0.5327
23	0.5501
24	0.1662
	3.9567 mg/m^2 /day, 0.0000457 mg/m^2 /sec

Spectral Properties

The amount of the light transmittance by the plastic cover is directly proportional to its wavelength. The least transmitted portion of light is in the violet blue wavelength (around 350 nm) increased gradually to the highest transmitted portion in the red wavelength (around 750 nm). For example, 40% of the transmittance light was at 350nm wavelength region increased to 67 and 77% as light wavelength increased to 550 nm and 75 nm region respectively. It also appears from the slope of the transmittance vs. wavelength curve Figs. 3(a) and (b) that the accumulation of dust particles on the plastic cover reduces such differences but only to a limited extent. It has been show that both chlorophyll a and b absorb light principally in the violet and blue wavelength and also in the red while their absorption in the other wavelength of the visible light is almost negligible (Gritton, 1989). Since the plastic cover transmitted more red lights relative to the blue light it makes the red component of the transmitted light more influencing in photosynthesis practically during the frost four weeks of the experiment. Fig. 3 shows that the percentage of transmitted light decreased with increasing dust accumulation with time. For instance, if the light transmitted at 550 nm wavelength is taken as an average for the whole spectrum of visible light, then the light transmittance went down for 67% after 2 weeks to 55, 27, 22 and 13% after 4, 6, 8, 10, and 12 weeks of radiation respectively.

Fig.3(a). Light trammittance through the undusty plasti at the site.



For undusted plastic the light transmittance was averaged between 75% after 2 weeks to 69% after 12 weeks at 550 nm wavelength. The light transmittance differences among weeks intervals were very little compared with dusty plastic covers. A minor decreased in light transmittance in undusted due to the plastic degradation by UV radiation through the time.

Solar Radiation Distribution

Fig. 4 presents the frequencies of days with various amount of solar radiation. The purpose of the data in Fig. 4 is to describe and interoperate the results. The distribution of solar radiation is shown to be bimodal. Low amounts of solar radiation are distinctly separated from the clear days. The amount of high range of solar radiation (10 – 21.9MJ/m2/d) frequencies in April are often compared with that in January which more frequencies low range of solar radiation (4.0 – 13.MJ/m2/d).

Fig.4. The frequenciesof days with various amount of solar radiation during the growning season.

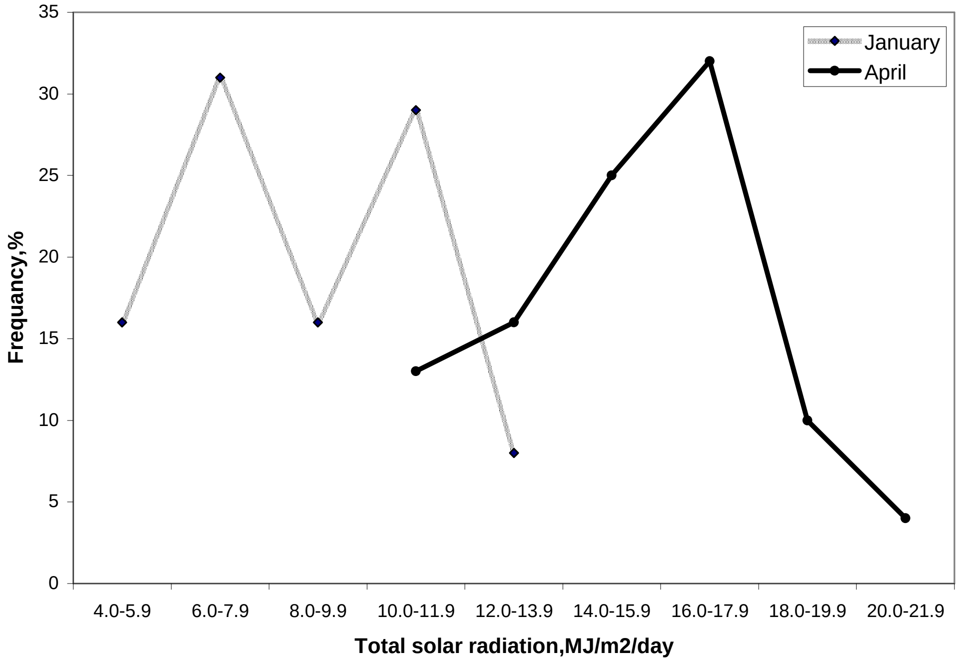


Fig. 3(b). Light tramsmittance of Dusty plastic

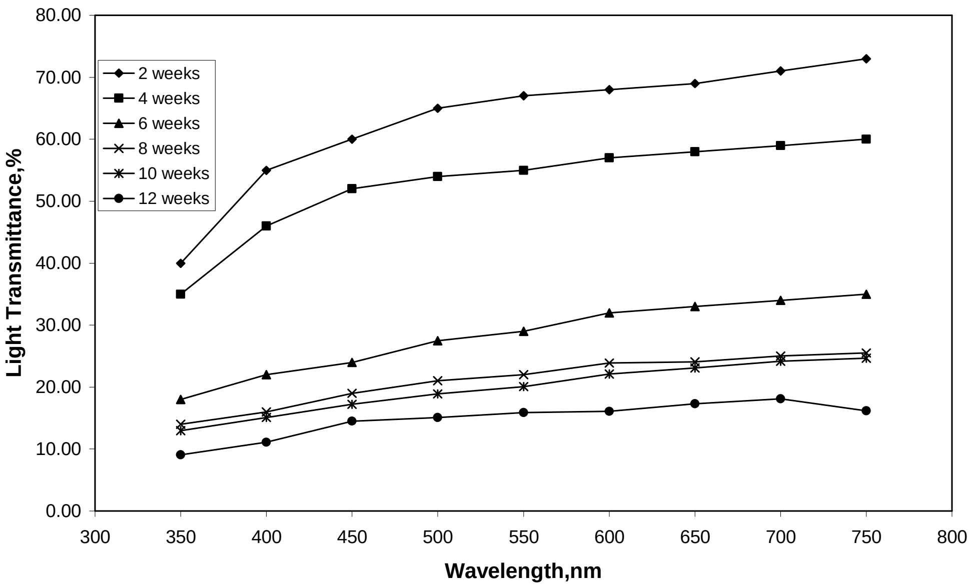
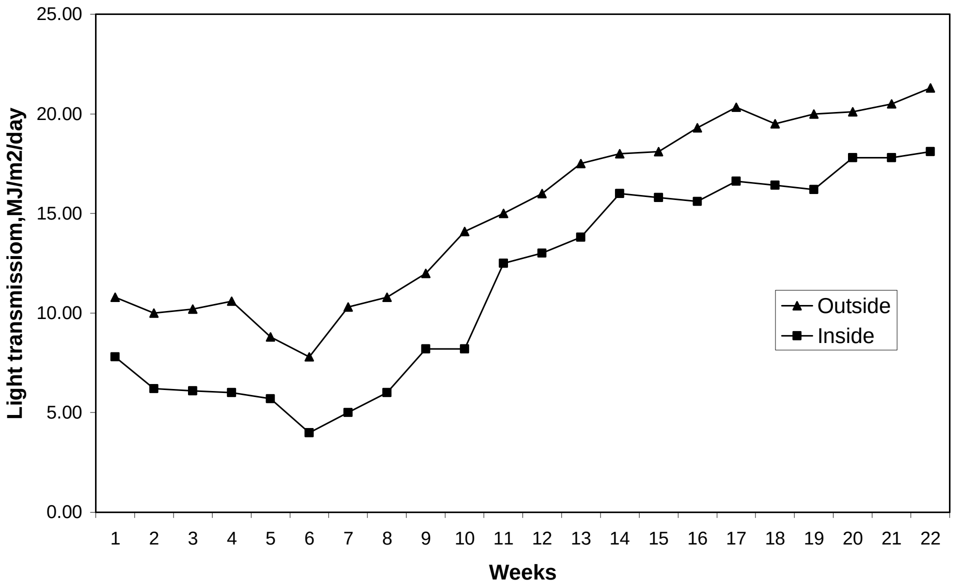


Fig. 5 illustrates the outside and inside weekly average of daily total solar radiation. Solar radiation ratio if defined as the proportion in percent of amount of solar radiation(MJ/m^2/day) available inside the greenhouse to that available in the outside the greenhouse (Fig. 6). Daily solar radiation ratios in the greenhouse ranged from 40 – 86% for January and May respectively, averaging 74%. Solar radiation ratio increased changes from January to May due to the changing in solar elevation.

Daily mean air temperature reached the minimum (11.2C to 15.1C during January for outside and inside the greenhouse respectively, while the maximum values (32.4C to 36.2C) during May for outside and inside the greenhouse respectively.

Fig. 5. Wekly average of daily solar radiation of inside and outside of the greenhouse.



Albedo Estimation

Some of the radiation reaching the surface is reflected. The fraction of reflected radiation by the surface depends on the nature of the soil as well as on the density and quantity of vegetation. Monthly average of diurnal values of albedo inside the greenhouse is calculated for each month of recording period and presented in Fig. 7.

Fig.6. Lifgt ratio between inside and outside the greenhouse.

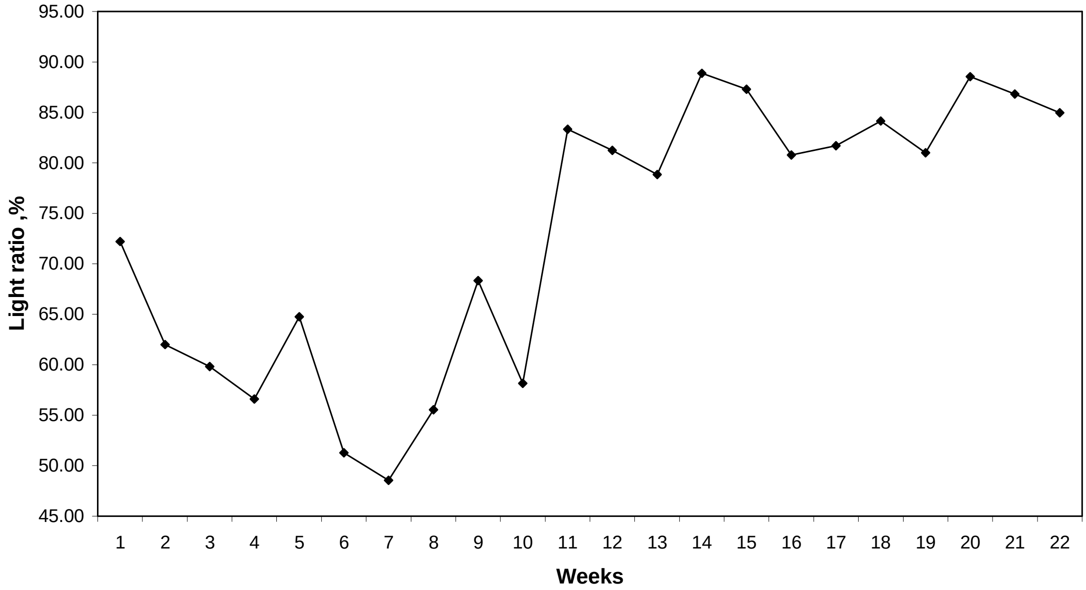
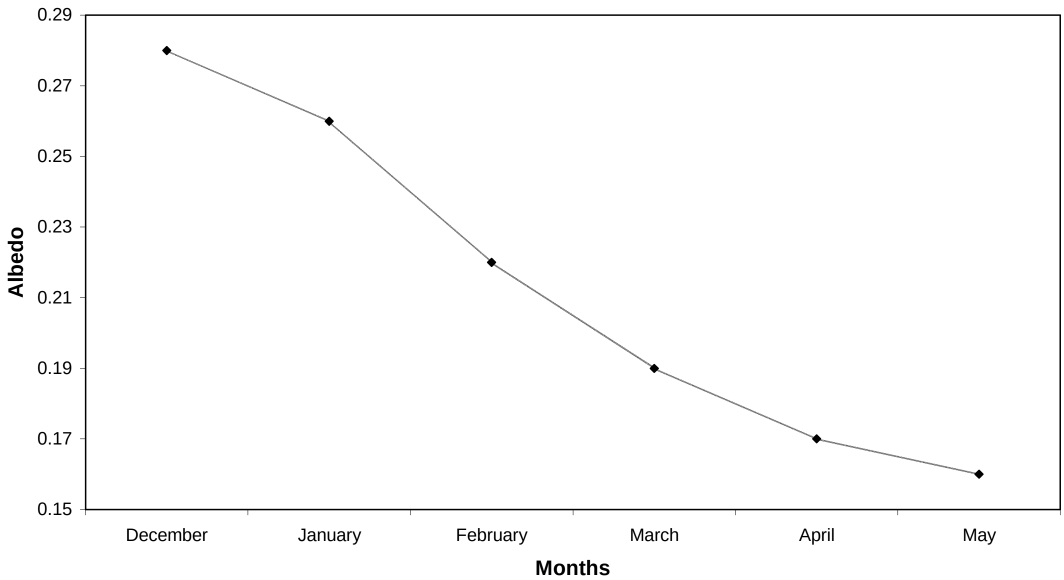


Fig.7. Monthly average of albedo inside the greenhous.



The calculating method used by Fritschen, (1967) who calculated the average of albedo of the whole day as the ratio of daily total reflected shortwave radiation to the ancient solar radiation. The values indicated that there is very noticeable diurnal variation between months of the growing season, where by for low elevation (solar attitude below 30o0 albedo rises quite significantly.

Some of this variation may be due to crop development and general surface quality. Part of this rise has been explained by Fritschen, (1984) as due to reflections with the upper half of glass dome enclosing the pyronometre sensor.

Changes in Soil Carbon-Nitrogen Stocks

The study land is dry with loosely packed sandy soils and strong winds. Wind speed over the area is around 36 -56 km/h at 10m height and 1.2 – 2.1km/h at the soil surface (Hasson, 1999). Due to heavy grazing by sheep grass beds and seeds have been lost. Nearly one third of the land area is occupied by annual and perennial pastures. Organic materials make up 7.75 percent of the accumulated dust. An average of 0.299mg /m^2/day of organic materials has been lost from the original soil surface by wind erosion.

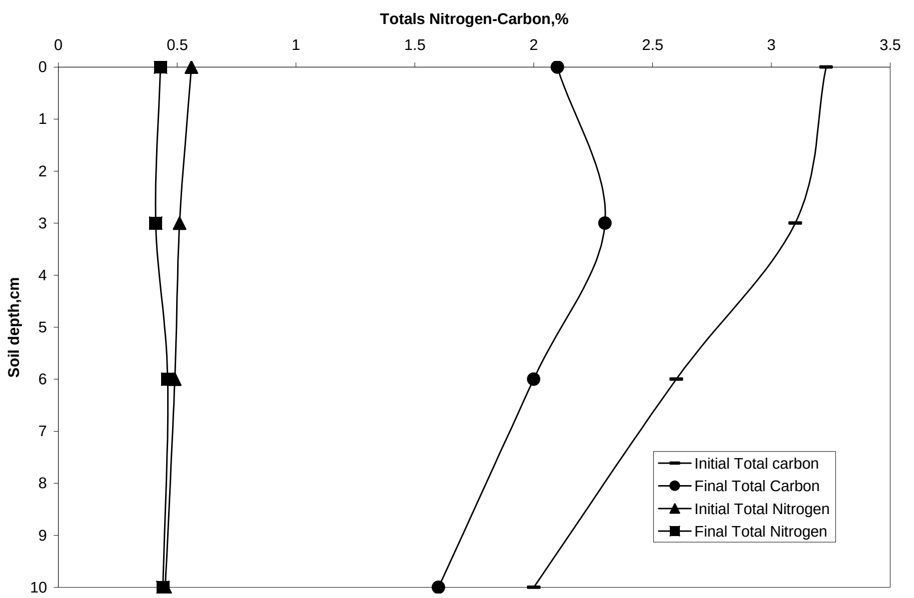
Figure (8) shows the results of the average of soil total carbon and total nitrogen changes at 0-10cm depth and indicates that most of the losses occurred at 0 – 6cm depth.

The amount of soil total carbon and total soil nitrogen removed from the soil were 86% and 73%, respectively. There were no significant differences in carbon and nitrogen depletion beyond 10cm depth. Wind erosion may have a significant impact on the soil carbon and nitrogen stocks. The loss of carbon and nitrogen from the surface soil in the study area can be classified as critical.

The establishment of a biodiversity belt containing eucalyptus and native trees may reduce the wind speed. No tillage and natural soil mulching may reduce the wind erosion impact on the land. Intensive management is likely to sequester carbon following implementation of improved grazing management GiM (Conant et al., 2000).

This information provides a good view on the land degradation caused by wind erosion that results in the loss of top soil and consequently the depletion of soil carbon and nitrogen stocks. Although uncertainty exists with regard to the causes of climate change and global warming and the possible consequences, there is agreement that there are some impacts and we need to reduce these forms of carbon loss and land degradation.

Fig. 8. The differences between initial and final soil tests of total carbon and nitrogen



Plant Growth

Taking into the account the reduction in light transmittance due to the natural degradation of the plastic cover during 12 weeks of the growing season which amount to about 75 the reduction in light transmittance caused by dust accumulation of the plastic cover after 12 weeks period wound amount of about 60%. This means that more than one half of the light energy necessary for photosynthesis is absorbed by the dust particles and accordingly the photosynthesis is expected to be reduced**.** The expected reduction in the rate of photosynthesis caused by low light density, as a result of dust accumulation, can not be compensated by increasing the temperature inside the greenhouse because increasing the rate of photosynthesis with increasing the temperature is always associated with high light density (Kozai, et. Al, 1988).

Table 2 shows the evolution of shoot and dry weights, Total leaf area and yield capsicum plant grown under greenhouse environment. Shoot and dry weights as well as leaf area were significantly affected by the dust pollution, showing decrease with the increase dust accumulation. Capsicum yield followed similar pattern of shoot and dry weights and total leaf area. This could due to the modification of plant micro-environmental intercept to the light transmission.

This type of information would be most useful in controlled experiment to simulate natural conditions inside the greenhouse and in determining the amount of cutting needed to obtain given amount of radiation in order to make suitable environment for plant growth inside the greenhouse.

Table 2. The effect of dusted and undusted on the shoot, dry and yield weights.

Plastic Conditions	**Shoot, Dry weight, g/plant**	**Root, Dry weight, g/plant**	**Total Leaf Area, d/m^2**	**Yield, kg/ m^2**
Undusted	110	20.6	29.1	4.2
Dusty	85.5	12.4	18.8	2.8

Conclusion

Dust particles from an obstruction layer on the plastic covering preventing 60% of the visible light necessary for photosynthesis process from penetrating the plastic cover and reaching the plant. Cleaning the transparent greenhouse cover throughout growing season is expected to be beneficial.

The area is in critical level because of the wind erosion. Total carbon and total nitrogen elements of the upper surface are affected significantly. Carbon sequestration is needed seriously.

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