Use of coal ash to stabilize soil surfaces by enhancing development of biogenic crusts

Eli Zaady[1], Shlomo Sarig[2], Itzhak Katra[3], Naftali Goldshlager[4], Daniel Barkai[1]

[1]Department of Natural Resources, Agricultural Research Organization, Gilat Research Center.
[2] Katif Research Center - Sdot Negev.
[3]Department of Geography and Environmental Development, Ben-Gurion University of the Negev.
[4]Soil Erosion Station, Ministry of Agriculture.

The Workshop on Agricultural Uses of Coal Ash
Volcani Center, Israel
27 June 2014

Background

The sandy soils in the north-western Negev are naturally stabilized by biogenic crusts (formed by photosynthetic microorganisms), as long as they are not exposed to anthropogenic disturbances.

The natural landscape of the sand dune area of the north-western Negev covered with biogenic crusts

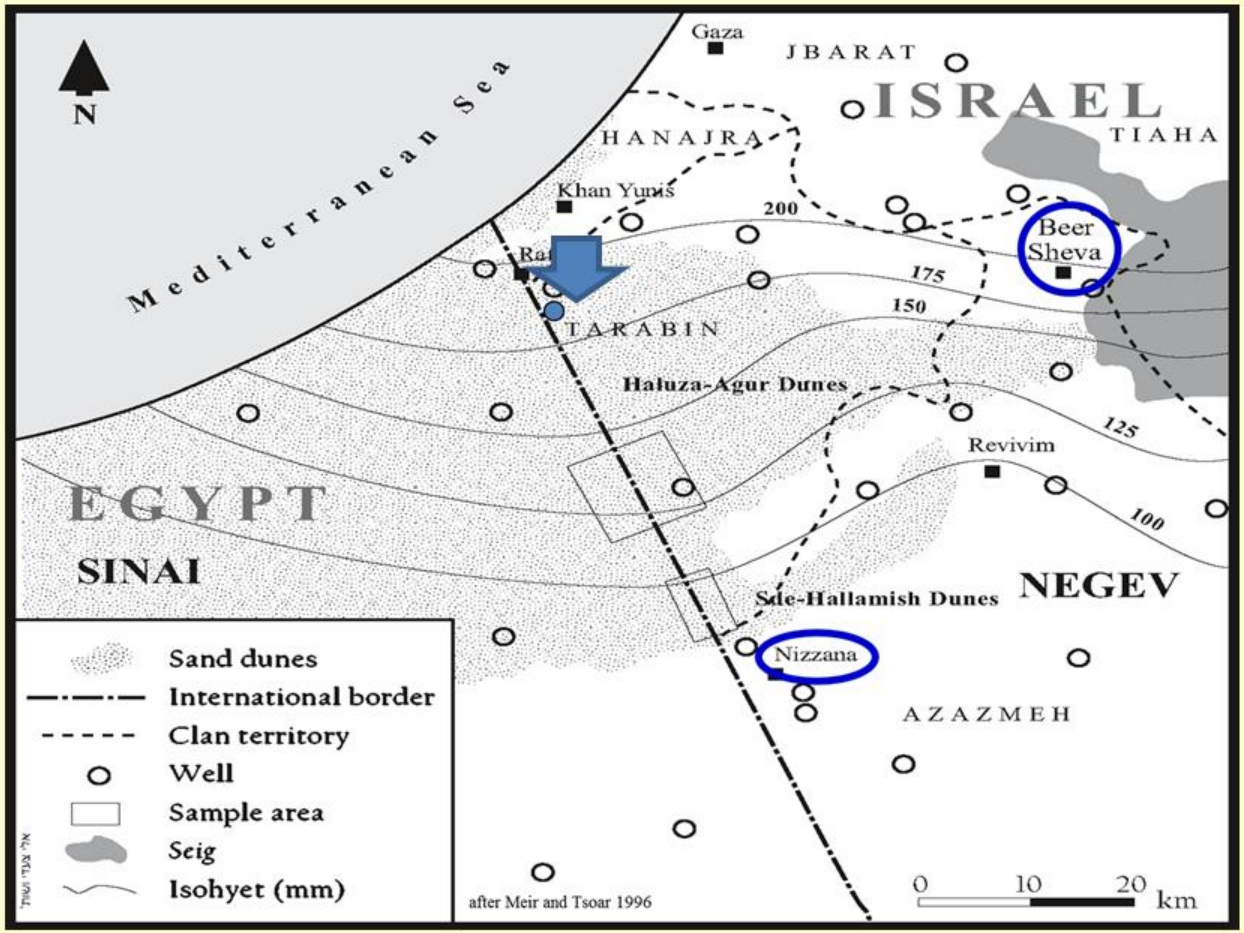
Background

The sandy soils in the north-western Negev are naturally stabilized by biogenic crusts (formed by photosynthetic microorganisms), as long as they are not exposed to anthropogenic disturbances.

The natural landscape of the sand dune area of the north-western Negev covered with biogenic crusts

Background

Recently, an area of 20 square kilometers of the sandy dunes, has been prepared for agricultural settlements. The natural landscape in the area comprises of stable sand dunes that are still undergoing development and preparation for agricultural purposes, involving leveling the surface with heavy equipment.



Background

Recently, an area of 20 square kilometers of the sandy dunes, has been prepared for agricultural settlements. The natural landscape in the area comprises of stable sand dunes that are still undergoing development and preparation for agricultural purposes, involving leveling the surface with heavy equipment.

Background

The preparation for agricultural are affects the soil surface's natural stability, and exposes the agricultural land to wind erosion and to sand grain migration, which damages crops and vegetation.

This has severe economic implications.

Moving sand covering the agricultural fields.

Objective

To use the flying coal ash to stabilize soil surfaces by enhancing development of biogenic crusts in order to decrease crop damage.

Methods and Materials

The research includes four phases:

a. Laboratory experiment,

b. Wind tunnel experiment,

c. Field experiment,

d. Aeolian greenhouse experiment.

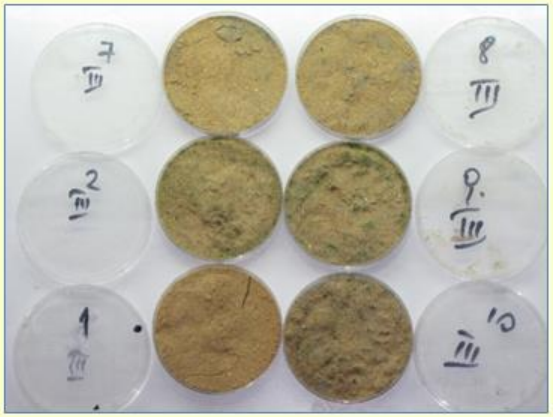
Laboratory experiment

We compared between addition of flying coal ash, inoculant, coal ash + inoculant and control-sand for determining the amount of coal ash needed, by measuring common biogenic crust growth parameters [the levels of polysaccharides and chlorophyll - lab extraction and NDVI index] and soil surface stability.

It was found that:

a. The coal ash did not prevent cyanobacterial growth.
b. No differences were found between 2 to 4% ash relating to cyanobacterial growth efficiency.
c. In all the treatments, an increase of growth parameters was obtained, contributing to soil surface stability, compared to control-sand.

We concluded that 2% (w/w) of flying coal ash + inoculation will be used.



Wind tunnel experiment

The second phase was conducted in a wind tunnel.

- The experiment in growing trays was conducted with an addition of 2% of flying coal ash.
- The trays were transferred to growth chambers with continuous illumination.
- After two months the trays were transferred to the Aeolian Simulation Laboratory at Ben-Gurion University for testing the crust survival strength in different wind intensities, corresponding to the wind velocities in the north-western Negev area.

Wind tunnel experiment

Trays (0.5x1.0 m) with a sand layer of 1 cm were grown with 2% coal ash with and without inoculant compared to control-sand.

We measured biogenic crust growth parameters [the levels of polysaccharides and chlorophyll - lab extraction and NDVI index], and stabilization of the soil surface.

Results of the wind tunnel experiment

The levels of polysaccharides and chlorophyll [lab extraction and NDVI index] compared to control-sand were measured.

It was found that:

In all the treatments, when the sand was inoculated by cyanobacteria and/or coal ash, an increase of growth parameters was obtained, contributing to soil surface stability, compared to control-sand.

We concluded that the wind tunnel experiment showed the importance of the biogenic crusts ± coal ash in preventing soil erosion.

Quantitative simulation - aeolic drift of sandy soil

Testing for applied feasibility was done in two phases:

A. In the sand dune area where agricultural land is being prepared, and

B. In an aeolian greenhouse facility.

Both experiments include the addition of coal ash to the experimental plots at the optimal level as obtained in the laboratory and the wind tunnel experiments.

Field experiment

Aeolic simulation was done by using a movable wind tunnel at the sand dune. Four treatments were prepared:

a. Flying coal ash [2%]*,

b. Flying coal ash with cyanobacterial inoculation*

c. Cyanobacterial inoculation,

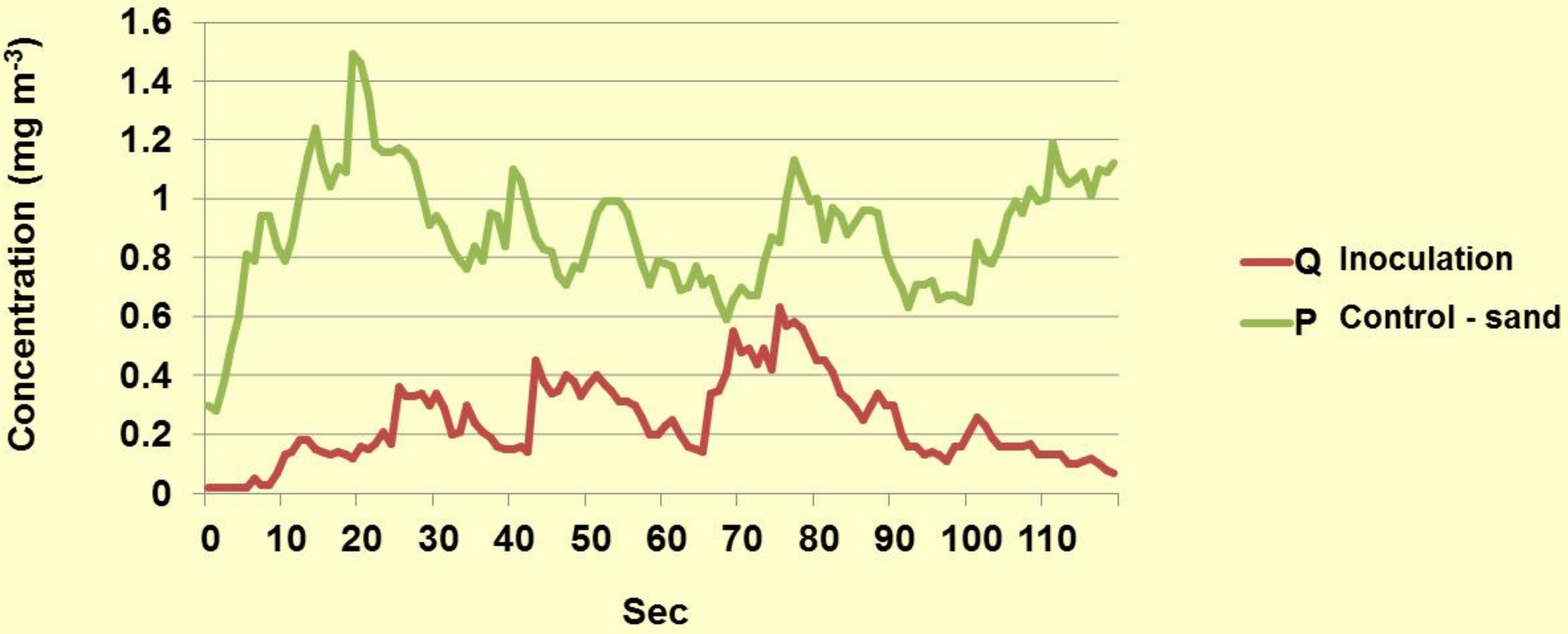
d. Control-sand.

The goal was to find the best treatment for stabilization of soil surface from aeolic erosion by analyzing:

- **Sediment erosion at 4 heights above ground: 3, 8, 15 and 35 cm.**
- **These values were in wind velocity of 4, 6, 8 and 10 m/sec.**
- **Each velocity was tested for 120 seconds.**

Quantitative simulation - aeolic drift of sandy soil

PM10 in wind velocity of 10 m/sec



At 10 m/sec an increase was found in PM10, in the control-sand.

The peak of the control-sand was at 1.49 mg/m^3. Q presented a peak at 0.62 mg/m^3.

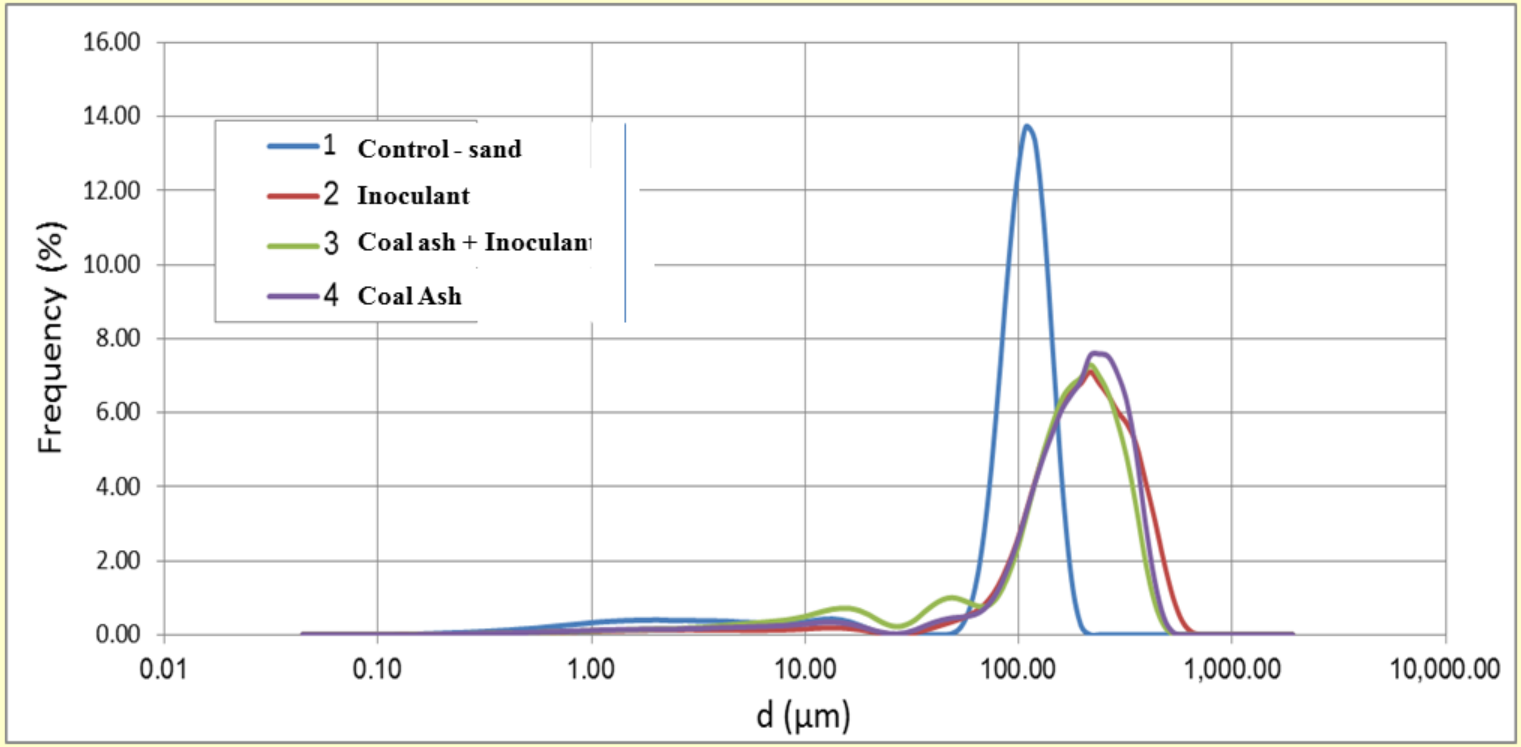
Quantitative simulation - aeolic drift of sandy soil

Aeolian greenhouse experiment

Quantitative simulation - aeolic drift of sandy soil

Aeolian greenhouse experiment

Saltation [horizontal flow]



The impact of aggregated particles compared to the control-sand is seen very clearly.

Large size aggregates can resist to wind erosion more easily than a sole sand grain.

Conclusions

a. Laboratory experiment:

- **2% of flying coal ash + inoculant is the amount needed to stabilize soil surfaces by enhancing development of biogenic crusts.**

a. Wind tunnel experiment showed:

- **the importance of the biogenic crusts ± coal ash in preventing soil erosion.**
- **the contribution to soil surface stability.**

c. In the field experiment:

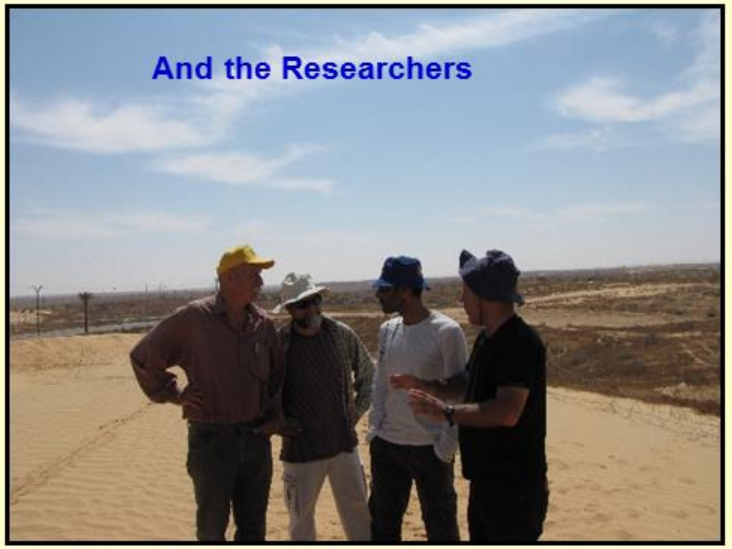
- **the untreated plots showed a lack of stability and relatively high erosion vulnerability.**
- **biogenic crusts is important in preventing soil erosion.**

d. The levels of polysaccharides and chlorophyll and NDVI index in all three treatments [coal ash, inoculant, coal ash + inoculant] compared to control-sand, showed an increase of all growth parameters and a contribution to soil surface stability.

e. The major impact of adding coal ash to the sandy soil surface is the rapid enhancement of soil stabilization.

Research teams:

Soil Erosion Station - MOAG



Thank you

This research is supported by the
Israeli National Coal Ash Board [NCAB]