Project Brief

Evaluating Green Compost and Zeolite to Enhance Soil Quality for Dubai Sustainable City

Climate change impact and increasing water demand in urban landscapes for sustainable city development call for innovative research on water saving and environmental protection. The urban landscapes are usually prepared using sweet sand from the deserts. In the United Arab Emirates (UAE) the soils are dominantly sandy and infertile, which requires frequent irrigation due to hot climatic conditions. To be cost-effective in terms of water use, urban landscapes need techniques to improve soil quality that require less water and absorb nutrients better.

One of the ways of water saving is improving the water use efficiency by enhancing soil water retention capacity. In the past, a number of organic and inorganic amendments have been used to improve water and nutrient use efficiencies. However, little has been done in this respect on the UAE soils for urban landscaping projects such as Dubai Sustainable City. The International Center for Biosaline Agriculture (ICBA) worked with Tadweer Waste Treatment L.L.C. to study the effect of organic (compost) and inorganic (zeolite) amendments provided by Tadweer Waste Treatment L.L.C. on enhancing soil quality for sustainable urban landscape development in Dubai Sustainable City. The approach of the study consisted of two parts: characterization of the products (compost and zeolite), and testing of the products for their ability to retain water under different treatments (mixes of different quantities of the products), and different irrigation applications.

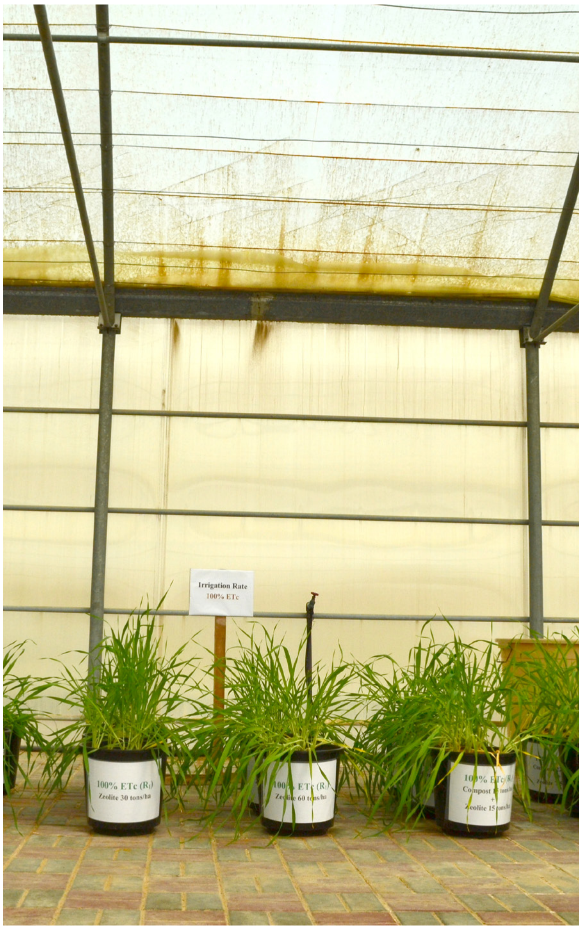
Activities and Outcomes

Physical and Chemical Characterization of the Soil: Compost and Zeolite

Complete Particle Size Distribution Analysis (PSDA) was carried out by using the standard pipette method supplemented with wet sieving (that allows quantification of sub-fractions of sand). The data (sand, silt, clay) presented is less than 2 mm basis (oven-dry basis). Textural class is reported by plotting the sand (2-0.05 mm), silt (0.05 to 0.002 mm) and clay (< 0.002 mm) values on the textural triangle (Soil Survey Division Staff 1993). The pH was measured on a saturated soil paste (pHs) and electrical conductivity in the saturation extract (ECe) collected from the saturated soil paste under vacuum. The extracts collected from various treatment mixtures were analyzed for solution chemistry (soluble Na^+, K^+, Ca^{2+}, Mg^{2+}, CO_3^{2-}, HCO_3^-, Cl^-, SO_4^{2-}) using standard procedures (Burt 2004; US Salinity Lab. Staff, 1954). The pH and EC (green compost) were also measured on soil: water (1:5 and 1:10) extracts. The calcium carbonates equivalents were determined by the standard calcimeter procedure, where a known amount of soil when reacted with 1N HCl, and the CO_2 produced was measured and converted to $CaCO_3$ equivalents. Water retention at 0.1 bar (field capacity) was measured using the pressure membrane apparatus. Elemental composition was determined using X Ray Fluorescence (XRF) equipment at Dubai Central Laboratory.

Water Retention:

When water is applied to the soil, either through irrigation or rain, it redistributes itself in the soil along energy (potential) gradients. Initially, the rate of downward movement into the soil is rapid. After the cessation of irrigation, the water redistribution process continues until all the large pores are filled (usually over a period of 24-48 hrs, less for sandy desert soils). The remaining water, in small pores, is retained by capillary and surface forces.



Pot experiments were carried out in the greenhouse at ICBA.

Thematic area: Assessment of Natural Resources in Marginal Environments

Purpose: Improve nutrient and water use efficiency of sandy soil for forage production

Geographic Scope: United Arab Emirates

Timeline: 2014 - 2015

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For this water to be removed from the soil, energy must be expended to overcome the capillary and surface forces which bind the water to the soil particles. The various energy units that can be used to express and describe the energy status of water in the soil used were cm of H2O (or cm of Hg), bars or atmospheres to express the energy status of water in the soil.

Field Capacity (FC):

Field capacity was defined as the percentage of water remaining after having been saturated and after free drainage has practically ceased. Under laboratory conditions soil-water content at 0.1 bar (for coarse textured soils), which corresponds to 100 cm of H2O, was used to approximate θFC.

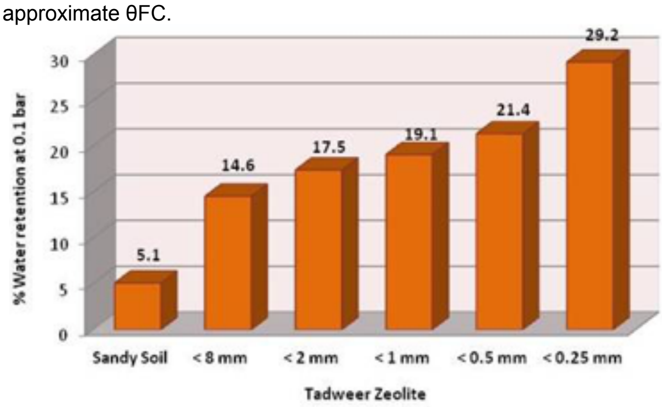

Figure 1: Comparative water retention at 0.1 bar (sandy soil and zeolite of different particle size grades).

Figure 1 on the water retention at 0.1 bar, which was determined using the pressure membrane apparatus, presents water retention of sandy soil used in the trial and different particle size grades of Tadweer Waste Treatment L.L.C. zeolite. It is apparent from the results that with the fineness of zeolite (Figure 2), the water retention increased consistently. Keeping the water retention (0.1 bar) of original (< 8 mm) zeolite (100%), an increase in water retention was recorded as 20, 31, 47 & 100% in zeolite grades of < 2 mm, < 1 mm, < 0.5 mm and < 0.25 mm respectively. This clearly showed that the efficiency of zeolite in terms of water holding capacity can be further increased (more than twice) by reducing the size of the bulk zeolite material leading to significant water savings. Compost retained 61% of water at 0.1 bar pressure, whereas the sandy soil used in the greenhouse experiment retained 5.1% of water. The trend of water retention can be explained as compost > zeolite 0.25 mm > zeolite 0.5 mm > zeolite 1 mm > zeolite 2mm > zeolite 8 mm > original soil (61% > 29.2% > 21.4% > 19.1% > 17.5 % > 14.6% > 5.1% respectively).

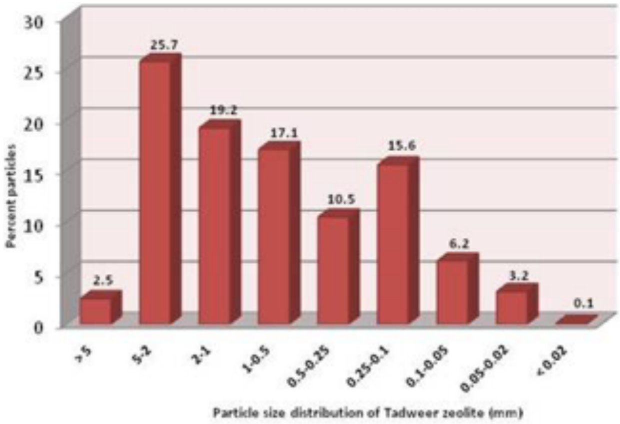

Figure 2: Particle size (mm) distribution of zeolite used in the greenhouse trial.

Greenhouse Experiment:

A pot experiment was conducted in the greenhouse at ICBA from November 2014 – February 2015 to evaluate the capacity of the products in retaining water under greenhouse conditions. A sandy soil (Typic torripsamments, mixed, hyperthermic) representing 75% of the UAE desert landscape was used in the trial. The green compost and zeolite provided by Tadweer Waste Treatment L.L.C. was mixed in different quantities with sandy soil to develop and study different treatments. Soil moisture in all pots was maintained up to 20 days from seeding followed by two irrigation treatments (100% crop evapotranspiration (ETc) and 75% ETc). The experiment received a standard mix of nitrogen (N), phosphorus (P) and potassium (K) and good quality water. The aim was to use good quality water to ensure that there are no other factors affecting the biomass production other than compost and zeolite. The crop used for the greenhouse trial was barley (*Hordeum vulgare* L.).

A barley variety (CM 72) was used to evaluate the performance of different mixtures of compost and zeolite on seed germination under laboratory conditions and forage production in the greenhouse trial. Seed germination was conducted in plastic trays using different treatment substrates and moisture was maintained at field capacity. Seed germination started on the second day of sowing and maximum seed germination was recorded at the end of the fourth day and response of seed germination was observed in the treatment mixture where a mixture of compost (22.5 t/ha) and zeolite (7.5 t/ha) was applied. Similarly, in the greenhouse trial, a combination of compost (22.5 t/ha) and zeolite (7.5 t/ha) demonstrated better results than other treatments and controlled treatment increased biomass by 53% and 59% at 75% ETc and 100% ETc respectively (Figure 3).

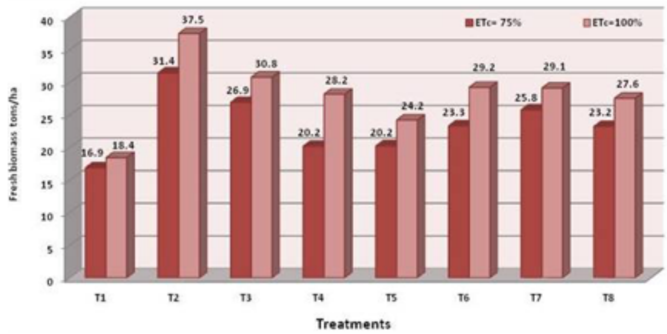

Figure 3: Comparison of biomass production with treatments and irrigation levels. (L-R: T-1T8) where T1 (control), T2 (compost @ 30 t/ha), T3 (compost @ 60 t/ha), T4 (zeolite @ 30 t/ha), T5 (zeolite @ 60 t/ha), T6 (compost 15 t/ha + zeolite 15 t/ ha), T7 (compost 22.5 t/ha + zeolite 7.5 t/ha), T8 (compost 7.5 t/ha + zeolite 22.5 t/ha).

The addition of compost and zeolite in different combinations increased the biomass from 20 to 86% over the control specification with the application of 75% ETc, whereas in case of 100% ETc application the increase in biomass production ranged from 32 to 104%. Researchers observed that when compost was mixed with zeolite it performed better and increased biomass over control at both water application rates. Thus, water can be saved using different amendments. The results obtained from the greenhouse trial can be extrapolated to benefit urban landscaping. The results of the study show limited irrigation with use of compost and zeolite increased the biomass over the control treatment, which suggests that further reduction of water application to 50% ETc may reduce biomass as close to control treatment, which will save water, reduce maintenance and protect the environment (urban landscapes).

Future Directions

These are preliminary results which need further verification in field trials. The most important component of future trials will be testing different sizes of zeolite and quantities alone and in combination with different quantities of compost for water saving, nutrient management, optimization and agricultural intensification.