NANOSHEL

White Paper

N-CLAY

LIQUID NANO CLAY

Soil Enhancer

Summary

Liquid NanoClay (LNC) is created when irrigation water and clay are mixed in a process. The mixing is done on site and the LNC is spread onto sandy soil using traditional irrigation systems like sprinklers or water wagons.

Inc is applied directly on top of dry, sandy land using traditional watering techniques (or direct injection into water irrigation systems). The mix saturates the soil to a depth of 40-60 cm retaining water like a sponge

Application of LNC in Desert Area as per Root Depth

Type of Plantation	Plant Root Depth	Recommended Usage LNC
Normal Trees (84-108 inches)	Very High Depth	4 Ltrs/Tree
Palm Trees (36-48 inches)	High Depth	3 Ltrs/Tree
Shrubs (18-24 inches)	Medium Depth	0.4 Ltrs/Sqm
Ground Cover (4-6 inches)	Low Depth	0.2 Ltrs/Sqm
Grass (1-2 inches)	Very Low Depth	0.2 Ltrs/Sqm

Solution

Liquid Nano Clay offers:

Soil Fertility

The LNC treatment creates an organic network perfect for plant growth. As such, when applied to desert sand, the crop yield of the sand is increased by up to 40%. This directly results in a higher yield of crops cultivated on the desert soil.

Water savings

The network created by LNC retains water more effectively than desert soil, offering a water saving of up to 65%. This results in less water requirement in farms. Considering that water is typically more costly in desert regions, such water savings translate to a huge cost reduction for the farmers.

Soil Fertility

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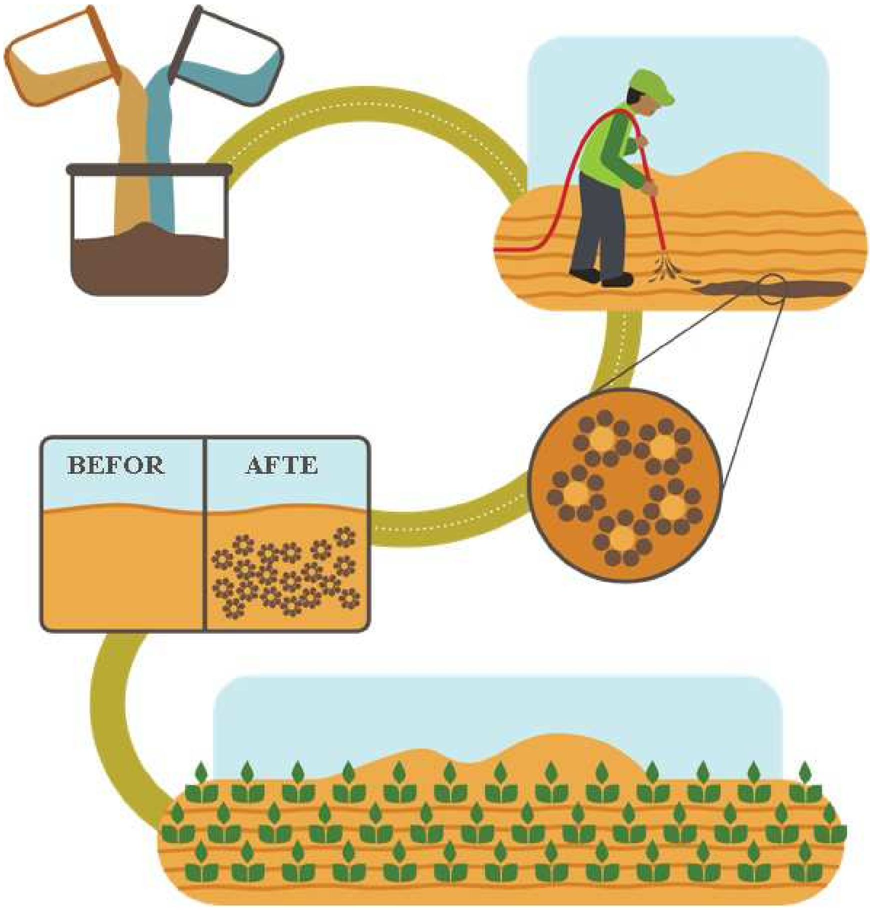
Competitive Advantage	Liquid Nanoclay	Clay Sand Mixture	Polymer Sand Mixture	Biopaste Sand Mixture	Bio Baskets	Bio Char
Immense water saving >50%	✓	-	-	-	-	✓
Possible to spray or Inject	✓	-	-	-	-	-
Requires NO Manual Mixing with Soil	✓	-	-	-	-	-
LOW Energy to Integrate or Mix	✓	-	-	-	-	-
Possible to Apply in Continuous Area	✓	✓	✓	✓	-	✓
Natural Product	✓	✓	-	✓	✓	✓
Uniform Application	✓	-	-	-	-	-
Complementary to All Fertilizers and Farming Methods	✓	-	-	-	-	-
Can be applied on existing greenery	✓	-	-	-	-	-
Can be applied using existing irrigation system	✓	-	-	-	-	-
Enhanced Nutrition Uptake	✓	-	✓	✓	-	-

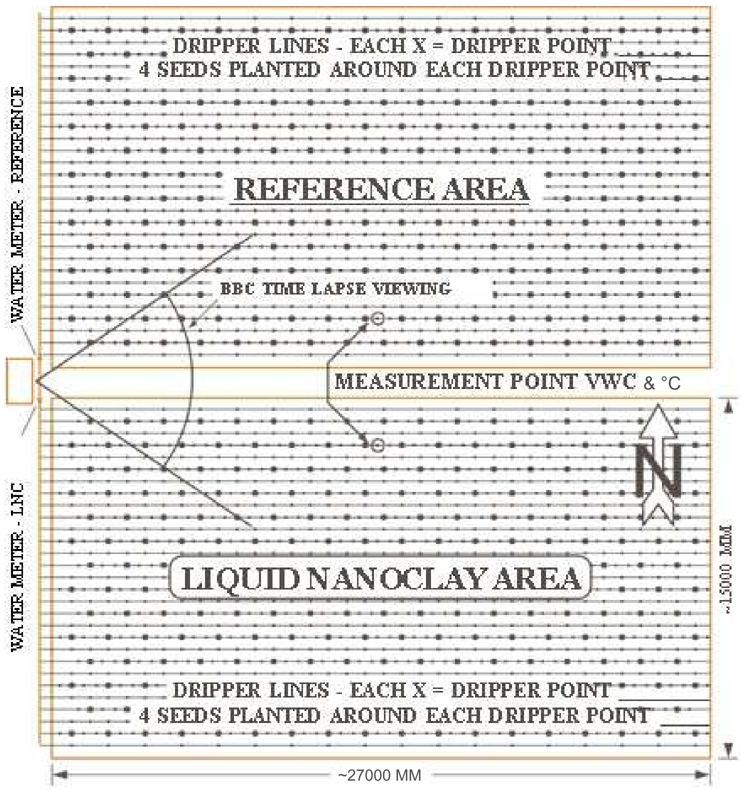
The LNC Treatment



The figure shows the process flow for the LNC treatment of farmlands. Mixing can either be off or on-site and the spray application can be applied using any conventional farm spraying equipment.

This mixing technique produces the ideal soil with a perfect mix of sand and clay, with the LNC covering the surface of each individual sand grain with the nanoparticles — just enough to adequately retain moisture and yet allowing for good ventilation. Thus, upon application of LNC, the sand turns into a sponge-like fabric that retains moisture/water and nutrients for a longer period of time. Consequently, LNC treated farmlands will require less water for irrigation, and cultivated crops are exposed to a higher quantity of nutrients — for an overall higher yield.

Test Methodology



The figure shows a scheme of the test area. Dripper areas are marked with “x”. 4 seeds are planted in each dripper point in both the reference and LNC treated areas.

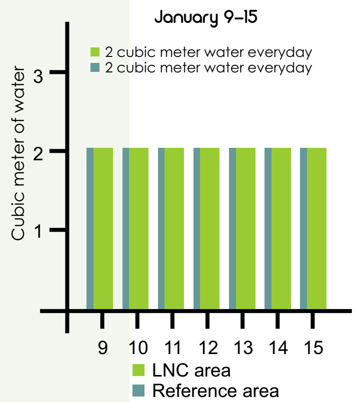
LNC mixing. LNC was mixed offsite at ambient temperature and pressure.

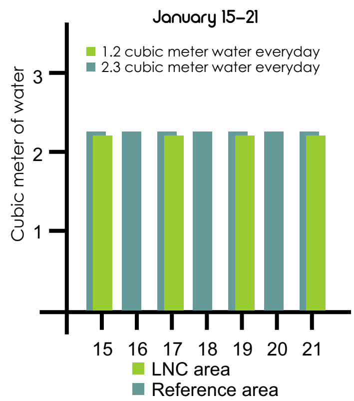
LNC application. After application of chicken manure (Al Yahar), LNC was injected to a depth of approximately 75 cm, using a rigid pipe connected to the end of a spray hose and inserted into the ground. Injection sites were ensured to always coincide with the position of the drip irrigation nozzles.

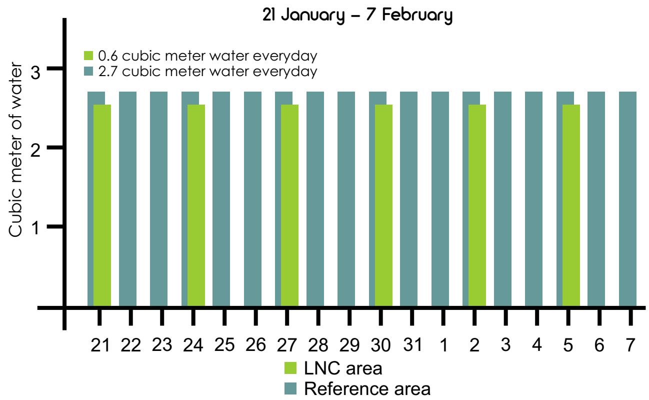
Root humidity and temperature measurements. VWC sensors were placed at depths of 10, 20, 30, 40 and 60 cm below the ground surface, while temperature sensors were placed at depths of 5, 15 and 30 cm. Both types of sensors were placed at locations around the irrigation nozzles. Humidity and temperature data were collected every hour and uploaded via a data logger.

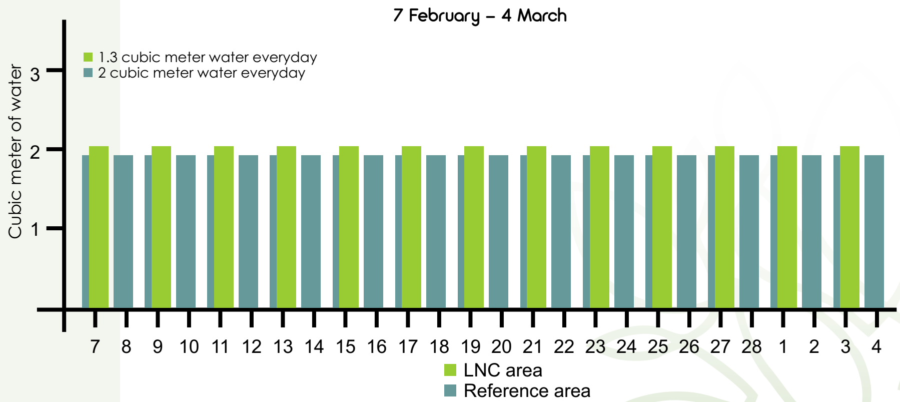
Watering schedule. During the whole experiment, the reference area was watered twice a day (morning and evening), while the LNC area was watered only once a day, once every second day and once every third day, during the 1st, 2nd, and 3rd periods respectively. The overall water consumption was measured through flow meters connected to the main supply pipe of each drip irrigation field

To further investigate the water retention capacity of LNC, temperature and humidity sensors were systematically placed at various soil depths in both the reference and LNC areas. Data collected during this test are segmented into four different periods with varying watering schedule. The periods and their corresponding watering schedules are shown in Table.







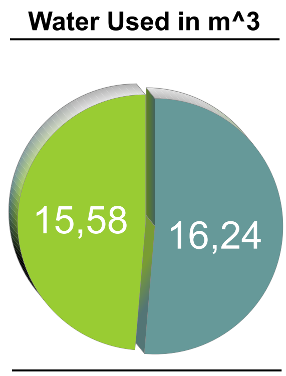


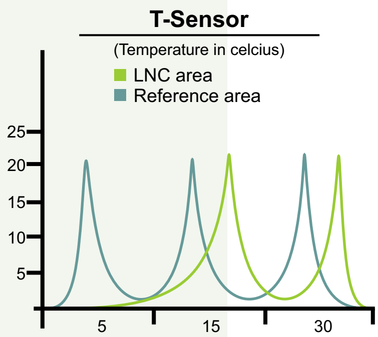
The table shows the four different test periods and their corresponding watering schedules for the reference and LNC areas. The bars represent the quantity of water introduced to the soil each day.

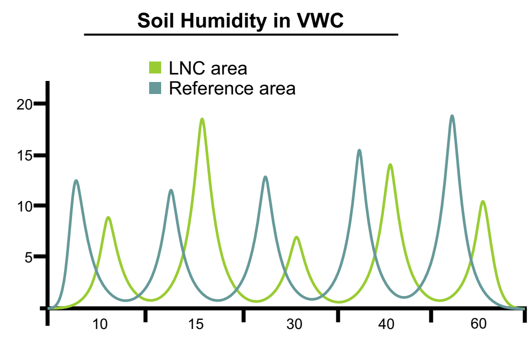
Period 1

Period 2nd to 9th January

During the test Period 1, the watering schedule and quantity across both areas were equal, hence there was no significant difference in soil temperature (see Fig. 8). However, while a linear increase of VWC with depth is observed in the reference area, in the LNC area, there is a spike in VWC at depths of 20 cm and 40 cm. The linear increase in VWC in the control area depicts how the top soil surface is more exposed to evaporation rates from the water table typically in the range of 2500 mm/year.1 On the other hand, spikes at depths of 20 cm and 40 cm demonstrate the water holding capacity of LNC at these depth levels. Comparing the VWC from both areas also suggests that the plants have their main water consumption at a depth of 30 cm. As such, the irrigation water percolates down, and the evaporated portion shows some condensation /LNC absorption in the 60 cm depth.



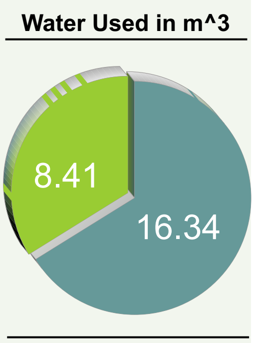




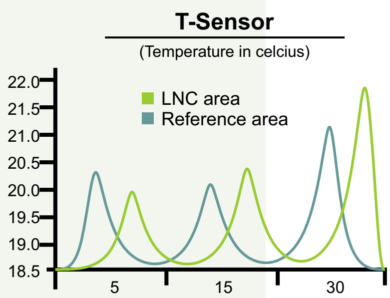
The figure shows the average soil temperature, and VWC as a function of soil depths (cm), and the total quantity of water used, during the test Period 1. The LNC area temperature value at a soil depth of 5 cm is omitted due to failed equipment.

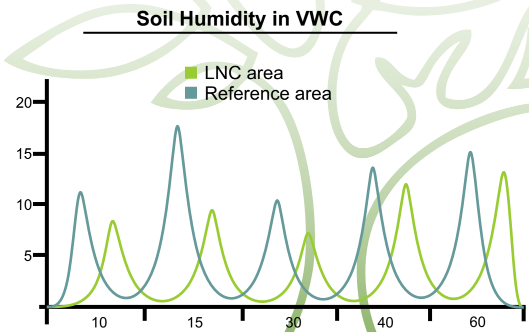
Period 2

Period 15th to 21st January



Soils in both areas are observed to be roughly of the same temperature during the test Period 2 despite the lower (halved) watering quantity and frequency in the LNC area, as shown in Fig. 9. VWC in the reference area portrays some linearity with depth. However, this time, there is a spike in VWC at a soil depth of 20 cm. This could indicate overwatering and a saturation of the absorption capacity at the top layers of the soil. In contrast, as expected, the LNC area shows a somewhat constant VWC across all depths, with a slight deep at the 30 cm depth level — substantiating the claim of the plant's root obtaining its water at that level.





The figure shows the average soil temperature, and humidity as a function of soil depths (cm), and the total quantity of water used during the test Period 2.

Period 3

Period 21st January to 7th February

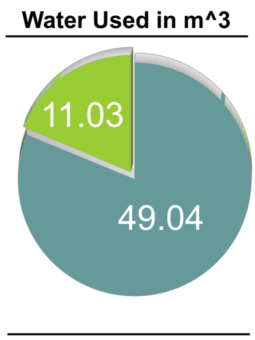
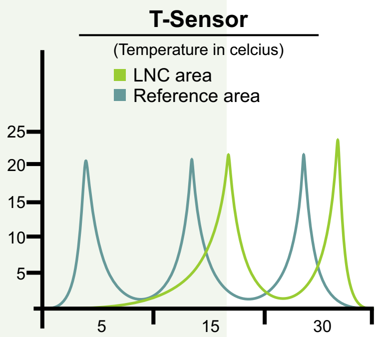
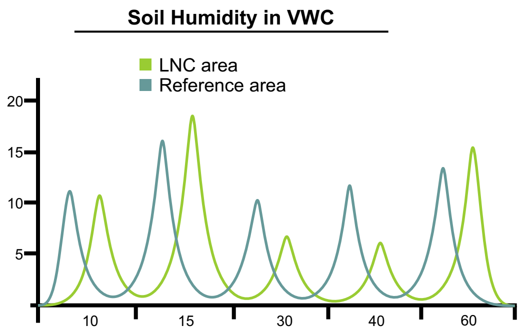


Figure 10 shows that temperatures measured during the test Period 3 are merely constant despite a 77.5 % lower irrigation quantity and frequency (watering ratio of about 1:5). During this period, both VWC plots show rather high VWC levels at 20 cm depth suggesting an overwatering scenario.

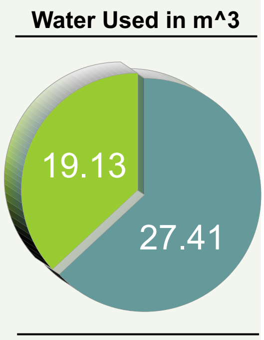




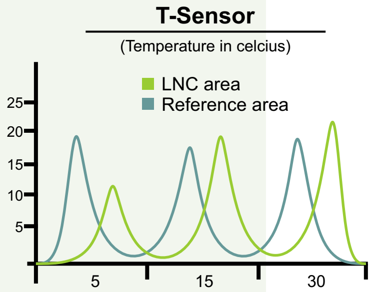
The figure shows the average soil temperature, and humidity as a function of soil depths (cm), and the total quantity of water used, during the test Period 3.

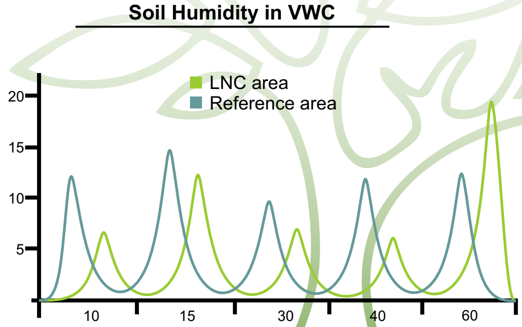
Period 4

Period 22nd February to 4th March



Test Period 4 maintains the constant temperature trend displayed in the previous periods, while the VWC values are similar to test Period 3 (see Fig. 11). The relatively high VWC at a soil depth of 60cm in the LNC area suggests the absorbance of water by the LNC layer from the ground water table.





The figure shows the average soil temperature, and humidity as a function of soil depths (cm), and the total quantity of water used, during the test Period 4. Note that data from 7th-22nd of January were lost due to some technical failures.

Conclusions

Feature of LNC

The ability of LNC to increase yield, while reducing irrigation requirement by up to 77.5 %, has been validated by the collected test data. Such capacity of the LNC is based on its ability to hold water for a long period of time to maintain the optimal soil VWC conditions.

Lessons Learned and Irrigation Scenarios

Period 1-4 show different irrigation regimes. Period 3 was closest to an optimum irrigation regime.

The irrigation schedule have to be optimized for different crops. Further studies will investigate the applicability of low water quantities delivered in shorter intervals for a more evenly distributed soil humidity profile. Temperature and VWC sensor data will be explored as an input for controlling the irrigation systems — using a automatically controlled feedback loop — in order to establish optimum irrigation regimes. The optimal regimes will then be prescribed to customers for subsequent use without the feedback control loop.

Futhermore, optimization studies have to be carried out for various mixtures and application techniques, soil irrigation depths, and the irrigation schedule for different air humidity levels.

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