Journal of Basic and Applied Engineering Research
p-ISSN: 2350-0077; e-ISSN: 2350-0255; Volume 10, Issue 2; April-June, 2023, pp. 104-108

http://www.krishisanskriti.org/Publication.html

Changing of Desert Landscape by Liquid Nano Clay

Sara Fatima

M.Tech, Department of Chemical Engineering, 2013
Aligarh Muslim University
E-mail: fsara4788@gmail.com

Abstract—*There are many nano materials used today to improve desert soil characteristics and increase crop yield. These nano-materials may be organic, inorganic and carbon-based or composite-based. They include nano-clays, nano-urea and nano-fertilizers. This review paper is a study of nano-clays for the improvement of soil and crop yield in desert landscape. Many operations are going on in desert countries like Desert Control® in UAE and Borgen® project in Saudi Arabia. Nano-materials are defined as microstructures having at least one dimension at a nano-meter scale. At the nano-scale; when used as prefix, denote* 10^{-9}. *At the nano-scale; all the electronic, magnetic, optical and chemical change occur at compounded and increased surface area. The main feature of nano-materials include small size, granulation distribution with a low level of agglomeration and high dispersion. These unique properties of nano-materials have led nano-technology to be incorporated into farming and agriculture in the form of nano-clay.*

Keywords: *Desert Control®, Borgen Project®, Liquid Nano-Clay, Nano Urea, Drought stress, Quality wheat, optimum moisture content.*

INTRODUCTION

Saudia Arabia is a desert country that saw its fortunes skyrocket due to the discovery of oil in the beginning of 20th century. It uses its billions of dollars of oil profits to power many parts of its economy and its citizens' lives. One of these facts is its food supply. The kingdom imports more than 80% of its necessary food supply with its oil money. Only about 1.5% of land area of Saudia Arabia is arable and the country ends up spending over 80% of kingdom's precious water supply. In Saudi Arabia, 1980s saw volatile food imports due to its global and political disturbance. The kingdom is still a major importer of cereals, meat, dairy products and fruits and vegetables, but there has been a growing emphasis on farming in Saudia Arabia as demand for food continues to rise. Satellite images have been taken in recent years to obtain an estimate of farmland area covered by cultivation. Borgen Project ®, Saudi Arabia has borrowed its idea of use of nano-clay from Desert Control® project running in its neighbor country, Arab Emirate. In UAE, a Norwegian scientist introduced his patented liquid nano clay to Emirati desert farms. LNC is a treatment that gives sand a clay coating by mixing nano-particles of clay with water and binding them with sand particles. Since sand particles are loose, they do not have water retention properties of soil or clay; thus decreasing NPK content of soil and hence decreasing the process of photosynthesis. Nano clay is produced by soil modification techniques such as adding cement or auxiliary chemicals (limestone, volcanic ash etc.) to soil composition.

LNC CHARACTERISTICS

The Liquid Nano Clay (LNC) is proprietary innovation of Desert Control® which enriches desert sand to fertility levels comparable to high quality farming soil — with a lower irrigation requirement and potentially higher crop yield. LNC operates by producing an optimal mixture of sand and clay that provides good moisture holding and yet airy soil. This process, which otherwise is very time consuming with mechanical equipment, takes only a few hours with LNC. Furthermore, LNC covers the surface of each individual sand grain with nanoparticles, while the old mechanical mix method just fills the gap between the sand particles and requires 10 times as much clay.

The LNC technology was originally developed in 2008 and has since been undergoing commercial assessments through laboratory and field trials. As a follow up to field tests in Egypt, China and Pakistan, the product was tested on a farm located in the UAE, to facilitate an entry into the Middle East market. This paper highlights the methodology, and results of this field test.

The test was carried out on an 800 m^2 area within the premises of an existing farm located in Al Ain, Abu Dhabi, and UAE. Sweet sand spread across the whole area was treated with a layer of chicken manure (approx. 0.5 kg per m^2), and half of the total area (400 m^2) was subsequently treated with LNC. To examine the effect of LNC on the yield of different vegetables, both areas were cultivated with the same quantities of cauliflower, okra (ladies' fingers), sweet peppers, and carrots for a period of 3 months (between 28th of November, 2017 and the 5th of February, 2018). During the cultivation periods, less water was applied in the regions where LNC was applied, in order to assess the water saving potential of LNC. The volumetric water content (VWC) and temperature measurements at the root level of the cultivated plants were monitored during the experiment, since they have a strong influence on the optimum irrigation schedule.

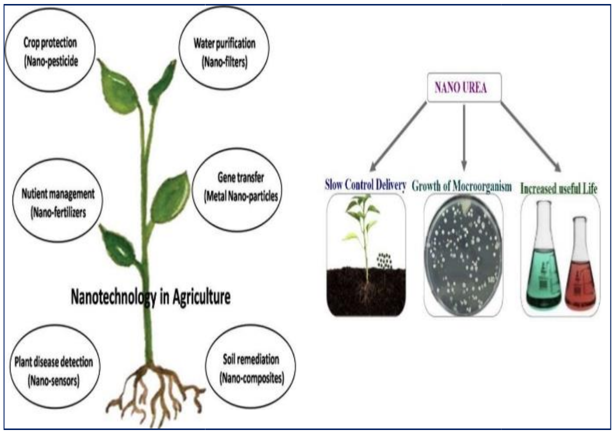

Fig. 1: Uses of nano materials in Agriculture

Results show that the average weight of the heaviest piece of cauliflower, okra, sweet peppers and carrots, harvested from the area treated with LNC, was higher by 109 %, 18 %, 64 %, and 17 %, respectively. Based on the VWC and temperature measurements at different soil depths, LNC allows for a reduced irrigation demand while maintaining the roots at temperatures equivalent to those of the control areas.

While these results portray an undoubted superiority of the generalized LNC mix for cultivating cauliflower, subsequent tests are required to optimize the mix ratio, materials and watering schedule for other crops. Watering quantities and schedules have to be optimized for the different seasons in the region. A technical evaluation of the VWC and temperature indicate that optimum irrigation would be to irrigate at the lowest soil surface temperature and irrigate to keep the VWC within 5 to 10%. This indicate optimum growth and optimum water savings potential.

RECENT RESEARCH ON LNC

Foeng Guo and Saman Aryana et al, in 2018, investigated three major arrangements of nano-particles, namely 1:1, 2:1 and 2:1:1 arrangements. Clays were classified as Clementine, chlorite, kaolinite, illinite and hallo site, depending upon their chemical composition and particle morphology. Cementite (or iron carbide) is a compound of Fe and C, more precisely an immediate transition metal carbide with formula Fe_3C. By weight, it is 6.67% Carbon and 93.3% iron. Chlorite is a clay mineral with $(Mg, Fe)_3(Si, Al)_4O_{10}(OH)_{2(}MgFe)_3(OH)_6$ as repeating unit. It is triclinic polymorph. Kaolinite is a clay mineral of chemical formula $Al_2O_32SiO.2H_2O$ that has a structure of 1:1 uncharged octahedral layer where each layer consists of single silica tetrahedral sheet and single alumina octahedral sheet. Illite is a clay material with mica-pyllosilicates having (K, H_3O) (Al, Mg, Fe) $_2(Si, Al)_4$ $O_{10}[(OH)_2, H_2O]$ formula. Halloysite is an aluminosilicate clay material with empirical formula $Al_2Si_2O_5$ $(OH)_4$. It forms by hydrothermal alteration of alumino-silicate minerals.

Iman Safarzadeh and Habib Rahimi et al investigated the effect of Nanoclay additives on the geo-technical properties of clay and silt soil. A series of tests were conducted including granulation, uniaxial, direct shear, atterberg limits, compaction and tri-axial tests on clay and silty soils. The results showed that the liquid and plastic limits of soil increased with increasing nano-particles in soil composition. Also, according to the results of compaction test, by increasing the nano clay, the unit weight of clay soil increased and optimum moisture content decreased. According to the results from direct shear tests, by increasing the nano-particles, the adhesion of clay and silt soils also increased. However, the internal friction angle of both clay and silt was reduced.

Iman Safarzadeh and Habib Rahimi et al also studied nano-clay using Mohr coulomb test. Mohr coulomb failure criterion is defined by two parameters: friction and adhesion. Generally, soils enriched with nano-particles have greater friction angle and greater adhesion and hence fail later than ordinary sand in Mohr coulomb test. This is due to the fact that the fastening and bonding between nano-particles and particles of soil increases and finally causes relatively thicker and denser masses in the soil. In other words, soil nano-particles increase the shear strength of soil due to the effect of interlocking in soil mass. The compressive strength and elasticity modulus increased with increase in Nanokaolinite content. This increase is high in silty soils and in clayey soils. Increasing the amount of Nano-kaolinite in clay soil causes a sudden increase in compressive strength and elasticity modulus.

Iman Safarzadeh and Habib Rahimi et al also studied nano-clay using hydrometer test. Hydrometer test of soil is based on Stroke's law, calculate the size of soil particles from the speed at which they settle out of suspension from a liquid. Results from the test showed the grain size distribution for soils finer than the Number 200 sieve. However, when combined with a sieve analysis, offer a complete gradation profile of soils containing coarser materials.

Iman Sarfarzadeh and Habib Rahimi et al also showed that because of their nano-scale dimensions and large surface area/volume ratio, direct shear test indicate that the clay and silty soil decreases with increase in Nano-kaolinite content. Atterberg limit test showed that liquid limit increased significantly after adding nano-clay, but not much change in plastic limit. Iman et al conducted Compaction test with the aim of obtaining optimum moisture content and maximum dry weight. Nano-clay decreases the optimum moisture content and increases the dry soil specific gravity. Increasing the amount of nano-kaolinite in clay soils causes a sudden increase in compressive strength, elasticity modulus and maximum dry weight. Iman et al also conducted uniaxial tests. They found that compressive strength and elasticity modulus increased with increase in nano-kaolinite content. This lead to increase in silty and clayey soils.

Acevedo Morantes et al studied characterization of nano-clays and incorporation in co-polymer of Styrene-Ethylene-Propylene-Styrene (SEPS). The resulting nano-clay was characterized by XRD (X-ray diffraction), SEM (Scanning Electronic Microscopy) and EDX (Energy dispersive X-ray spectroscopy) techniques. Two types of clays were used for these tests: cosmetic clay (sample 1) and molding clay (sample 2), to obtain nano-clays and determine the differences in their properties. Silver nitrate, hydrogen peroxide, sodium hydroxide, sodium chloride, ethyl-alcohol and hydrochloric acid were used. The SEPS polymer was donated by company, Kraton polymers and diethanolamine (DEA) has been provided by Pancreac Company. They found that SEPS copolymer can be used in wide range of applications such as thermo-plastic elastomers for impact modification and compression sensitive adhesion of nano-clays. SEM, XRD and EDX experiments were conducted. Two different types of clays(cosmetic and moulding) were used to prepare nano-clay that were modified with SEPS to increase their properties and be used in different technological applications and Al and Si mixed in SEPS copolymers were added to nano-clays so as to modify them. This resulted in modifying the polymer with these clays so as to have high inter-laminar space, confirmed incorporation hydrocarbon chains of the surfactant in the polymer nano-structure and agglomeration phenomenon after contact of this nano-clay with air.

Nano clays are layered mineral silicates with layered structural units, forming complex clay silicates. An individual layer unit is composed of octahedral or tetrahedral sheets. M. Calabi and Theng et al studied Liquid nano clay in Chilean environment. They studied how nano clay being applied to natural clay modifies its properties for the benefit of increased cultivation yield.They found Octahedral sheets consist of Aluminum or magnesium in a six fold coordination with oxygen from a tetrahedral sheet and with hydroxyl (OH). Tetrahedral sheet consists of Si-Oxygen tetrahedral linked to neighboring tetrahedral ; sharing three corners while the fourth corner of each tetrahedron sheet is connected to one octahedral sheet via covalent bond. The arrangements of these sheets impact various defining aspects of nano-clay materials. There are 30 different types of nano-clays based on their mineral composition, properties and application.

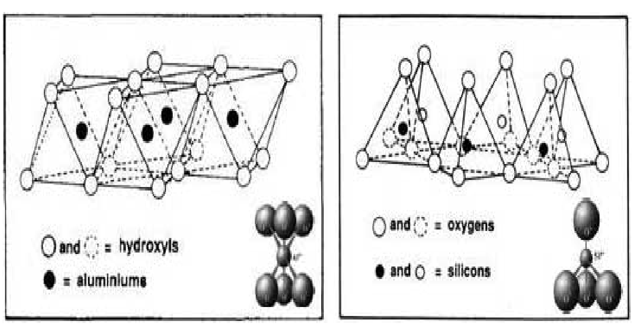

Fig. 2: Structure of an alumina octahedral sheet (left) and a silica tetrahedral sheet (right). (Adapted from McLaren & Cameron, 2000.)

LNC Field Test

The study was carried out on a farm located in Al Ain, Abu Dhabi, United Arab Emirates. Al-Ain is a town in the Emirate of Abu Dhabi located in the eastern part of the UAE. It is geographically located approximately 160 km east of the capital town Abu Dhabi and about 120 km south of Dubai. The eastern part of Al Ain spans over about 13,100 km. Oman lies to the east, Dubai and Sharjah to the north, Abu Dhabi to the west and the Empty Quarter desert and Saudi Arabia to the south. The city has a hot desert climate, featuring long, extremely hot summers and warm winters. In Al-Ain, the average relative humidity ranges from a low of about 20% in the summer months, to a high of about 60% in the winter months.

The study area, which is within the wider Arabian Peninsula, is considered water scarce due to its hyper-arid climate conditions. Average annual precipitation is less than 100 mm, while potential evaporation reaches 2500 mm in coastal areas. In the central parts of the Rub' Al-Khali desert, this number could be as high as 4500 mm / year -- due to the significantly lower air humidity in comparison to the coast.

Period. The experiment was divided in three main time frames according to different irrigation schedules for the **LNC area.** These time frames spanned across the following periods: (1) 09/12/17 - 15/12/17; (2) 15/12/17 - 21/12/17; (3) 21/12/17 - 07/01/18; (4) 07/01/18 - 04/02/18.

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.

Key invention component. Our invention is a novel technique of effectively mixing clay with water in a way that ensures the clay particles are perfectly distributed at the surface of each individual sand grain, to create complete envelopes around each grain. 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.

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 1.

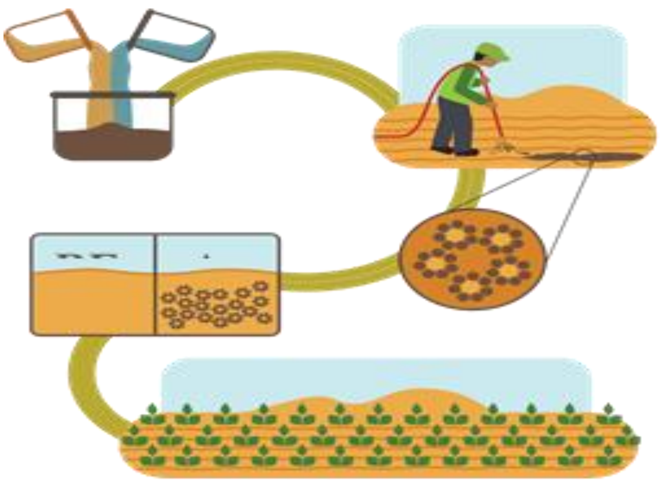

Fig. 3: Application of LNC to soil and farmlands.

Fig. 4. Desert Area under consideration of LNC Farming

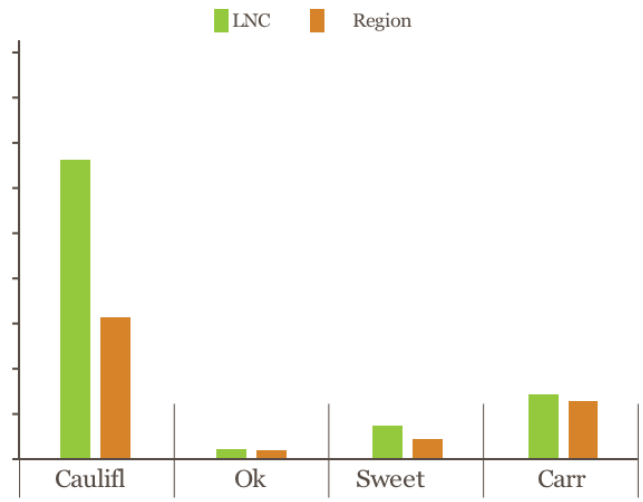

Fig. 5. Harvest or yield of heaviest vegetable piece obtained from cultivation of vegetables using LNC. Then compared with reference region.

Table 1: The table shows the four different test periods and their corresponding yield after LNC application to soil.

Reference Area	LNC Area
9 - 15 December 2 cubic meters of water every day	9 - 15 December 2 cubic meters of water every day
15 - 21 December 2.3 cubic meters of water every day	15 - 21 December 1.2 cubic meters of water average / day
21 December - 7 January 2.7 cubic meters of water every day	21 December - 7 January 0.6 cubic meters of water average / day
7 January - 4 February 2 cubic meters of water every day	7 January - 4 February 1.3 cubic meters of water average / day

CONCLUSION

Upon harvest, the weights of the individual crops were recorded as harvested from the LNC treated and control regions. Fig. 5 shows a comparison between the heaviest crops harvested from both regions — an indicator of the average weight of each harvest. Based on the data collected, the LNC area produces larger individual harvests. The heaviest cauliflower from the LNC region weighed 773 g while that from the control region weighed 369 g (i.e. less than half). There was no significant difference between the heaviest okra from the LNC and the control regions (LNC: 20 g; control: 17 g). The heaviest sweet peppers and carrots from the LNC region weighed 72 g and 157 g respectively, while those from the control regions weighed 44 g and 134 g, respectively.

LNC shows thus undoubted promise to improve the yield of cauliflower even under reduced water consumption. Further experiments are required to optimize mixing and cultivation parameters for okra, carrots and sweet peppers. Subsequent studies will investigate other vegetables common in the region. Definitely, LNC is changing the desert landscape to green pastures for prospective cultivation. It is helping in local produce of fruits and vegetables in desert lands and arid lands where earlier there was no scope of agriculture.

ACKNOWLEDGEMENTS

This work is a review work of one M. Tech student (author) on Liquid nano clay prospective agriculture in desert countries.

ABBREVIATIONS AND ACRONYMS:

LNC: Liquid Nano Clay
XRD: X-ray diffraction
SEM: Scanning Electronic Microscopy
EDX: Energy dispersive X-ray spectroscopy
DEA: Diethanolamine
SEPS: Styrene-Ethylene-Propylene-Styrene

REFERENCES

[1] A.C.D Morihama and J.C. Meirtzwa. Clay Nano particle effect on performance and morphology poly (vinyldene fluoride) membranes. *Brazilian Journal of Chemical Engineering, 15*, January – March 2014, pp 79-93.

[2] Jatav G.K, M Raj and Nirmal De. Characterization of swelling behavior of nano-clay composite. *International Journal of Innovative Research in Science, Engineering and Technology,* Volume 2, Issue 5, May 2013.

[3] Farida Bensadown, K. Nadir, B. Catherine, B. Simon, T. Francois and R. Edu. A Study of Nanoclay Reinforcement of Bio composites Made by Liquid Composite Molding. *International Journal of Polymer Science*, Hindawi Publishing Corporation, *2011*.

[4] Calabi B. M and M. Marla. Natural nanoclays: Application and future trends – Chilean perspective, Article of Clay Minerals, Research Gate, June 2009.

[5] Acevedo Morantes and M. Jimenez, International Journal of Applied Engineering Research, Volume 13, (16) 2018, pp. 12549-12552.

[6] B.H Sunil and M. Pushpalatha, Modi, Characterization of Nanoclays and Incorporation in Copolymer of Styrene- Ethylene-Propylene-Styrene (SEPS) and their application, *International Journal of Chemical Studies.* June 2018, pp 705-710

[7] S. Iman, Manbar HR and B. khalkhali, investigating the effect of nanoclay additives on the geo-technical properties of clay and silt soil, *Journal of Civil Engineering and Materials Application*, 28 May, 2019, 3(2), pp 65-77.