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Nemo's Garden- the world's first-and only-subterranean greenhouse (A review article)

Ningombam Sushma Devi*[1], Preeti Hatibarua[2] and Ningombam Bijaya Devi[3]

[1]Assam Agricultural University, Jorhat, Assam, India
[2]Department of Horticulture, Assam Agricultural University, Jorhat, Assam, India
[3]G.P Women's College, Dhanamanjuri University, Manipur, India

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ABSTRACT

The determinant factor of agricultural productivity is the Climate and any changes will affect and become challenging for agriculture. And the predominant causal factor for climate change is the emission of greenhouse gases into the atmosphere, mainly due to anthropological activities such as deforestation for conventional cultivation. As a result, it has become clearer by the day that there is a need to reform our food system from a conventional to a sustainable one. The Nemo's Garden, off the coast of Noli, Italy is a unique and futuristic underwater hydroponic farm for the cultivation of terrestrial crops which may provide an alternative eco-friendly and sustainable system to conventional horticulture, contribute to sustainable food production, with a positive effect on the surrounding environment. By harnessing the ocean's environmental benefits—temperature stability, evaporative water generation, CO_2 absorption, abundant oxygen, and pest protection—they aim to prove the viability of cultivating herbs, fruit, and vegetables underwater**.** The culinary herb basilwas initially taken as a model plant and is well adapted in the biosphere environment, but now other crops like strawberries, tomatoes, courgettes, beans, mushrooms, lettuce, stevia, aloe vera, orchids, etc are being successfully grown in the biospheres. The project is under research and pharmaceutical companies are willing to explore this alternative solution for growing plants and to reveal interesting discoveries for the future.

Key words : *Biospheres, Tree of Life, Hydroponic cultivation, Agrinauts*

Introduction

The increasing requirement for food and the adverse effects of climate change on agriculture demand new solutions.Crop production will become more challenging with climate change, paucity of resources (e.g. land, water, energy, and nutrients), and degradation of the environment (declining soil quality, increased emission of greenhouse gas emissions, and eutrophication of surface water). Intensive and industrialized conventional farming uses high doses of chemical fertilizers, and pesticides, and is considered a one-stop solution for food production for a rapidly growing world population, butis being carried out at the cost of the environment. The Nemo's Garden in Liguria, off the coast of Noli, Italy is a unique, revolutionary futuristic underwater hydroponic farm for the cultivation of terrestrial crops which may provide an eco-friendly and sustainable alternative system to conventional terrestrial horticulture, contribute to sustainable food production, with a positive effect on the surrounding environment.

The Nemo garden was first envisaged and set up

([1]Ph.D. Scholar, [2]Professor, [3]Assistant Professor)

in 2012 by Sergio Gamberini, the managing director of Ocean Reef (a scuba diving equipment company) just off the coast of Noli, in Liguria, Italy, designed with the novel and innovative concept to grow terrestrial plants underwater. The experiment started with growing basil, which is the most popular local culinary herb in the area, inside transparent biospheres filled up with air, 20 feet below the surface of the sea Pistelli *et al.*(2016).

Systematic experiments subsequently started in 2015 Dini *et al.*(2016) and observed the impact of the marine ecosystem on different terrestrial crop plants when they are grown underwater. With cultivable land becoming scarce, Nemo's project was initiated to substitute the conventional system of agriculture and design a system that can be implemented in areas with extreme environments (harsh climates), economical or morphological reasons (lack of arable land) that make conventional land agriculture extremely difcult,while utilizing already available natural resources i.e the oceans and other bodies of water.To further identify the pro and cons of this project, a study was conducted at Research Centre for Vegetable and Ornamental Crops (CREA-Centro di Ricerca Orticoltura e Florovivaismo) at Sanremo (Imperia, Liguria, Italy) where the same variety of Basil grown in both underwater and terrestrial environment was compared by analyzing their phytochemical, physiological, and micro-morphological characteristics Pistellia *et al.* (2020a).

The Structure

The structure of Nemo's Garden consists of 4 components Nemo's Garden (2021)

The Biospheres: The biospheres comprises of 6 air-filled clear and thick acrylic- plastic pods or domes(resembling large balloons), each 2 m diameter containing 60 seed beds on stilts which are fixed at the bottom of the sea (ocean floor). The 6 pods are arranged in a circle around a central flower-like structure (12 feet tall, 10-feet-wide metal, and weight half a ton) called the Tree of Life, which symbolizes evolution and signifies momentum toward the future. The Tree of Life acts as a center point from which important cables run to each biosphere. Meanwhile, the biosphere floats at a depth between 15 and 36 feet below the surface of the water and can hold approximately 2,000 liters of air. Sunlight flows through the water outside the biospheres to reach and heat the air within. When there is less natural light in the winter, LEDs attached to the surface by a power wire give an extra source of light Mc clatchie (2022). There is a step gridplatform installed inside the structure for the driver to stand and work inside the dome. Besides the warm and invariable sea temperature between day and night creates ideal growing conditions for the plants.

Communication: An underwater wifi communication network is installed for the scuba diver to communicate to the surface within 200 meters range of operation from the Tree of Life. Every operation including live video streaming of the plant can be done through an app on phone from the surface. Besides, the biospheres are equipped with 2 webcams and a wide-angle horizontal webcam at the bottom of the sea

The control tower: An above-water Control tower constructed on the shoreline helps to supervise the functioning of Nemo's Garden as well as to constantly stay in contact with the scuba-divers operating underwater and inside the biospheres, via the ultrasonic surface communication system and a full-duplex intercom communication system, respectively. The control tower is also equipped with 5 monitors, a laptop, and internet connectivity through a smartphone for transmission of live images and making Skype conference calls, etc. Constant monitoring of the underwater habitat (temperature, humidity, illumination, CO_2, and oxygen levels,)using underwater sensors take place. The control tower is also equipped with solar panels that control a fan in each biosphere to reduce humidity on the plants. In winter, when there's less natural light, LEDs connected to the surface by a power line provide an additional source of light. In addition, wind generators and solar panels situated on the control tower generate the power for lighting, pumps, and sensors.

Hydroponic cultivation: The plants are grown in 60 seedbeds in a 10m long spiral tube inside the dome. Seeds are planted inside a plastic cone containing a substrate (such as coconut Coir or Rockwool. An external water source is only required when initially growing the plants, but subsequently, water needed for irrigation is generated from condensed, evaporated salt water. This water along with the hydroponic fertilizer is stored at the lowest part of the spiral; a water pump drives the water up to the top of the spiral and delivers it to the plants. As water condensation takes place inside the inner wall of the biosphere, the condensed drip water then descends

the spiral by gravity and thus provide nourishment and oxygen to the plants.

Workers

A team of Trained deep-sea scuba divers (termed agrinauts) carry out the day-to-day operations of Nemo's Gardens, involving checking the anchoring systems, cleaning the biospheres of fouling, monitoring the sensor systems and assessing the health of the plants, intercultural operations and harvesting of the crops Smart (2019a).

Collaborative Research Work

The Siemens Digital Industries Software company, with its headquarters in Plano, Texas, USA created a digital twin of Nemo's biosphere. Their Simcenter STAR-CCM+ software is used to virtually simulate and monitor plant growth and environmental conditions within Nemo's "sub-aqua biosphere" domes. Thus, by using the digital twin, the team is no longer limited by weather conditions, seasonality, short growing seasons, or limitations on scuba diving to monitor the pods. In addition, Siemens' Industrial Edge computing devices will be deployed in each biosphere. They will leverage a machine-learning algorithm to automatically adjust air circulation, humidity, irrigation, and nutritional dosing throughout the season Seeley (2022).

Benefits of The Nemo's Garden

Self-sustainable: Agriculture makes up more than 85% of human water consumption, making it one of the most water-demanding human activities Aydinalp and Cresser (2008), but Nemo's Garden utilizes only natural resources, i.e. desalinated seawater obtained through the evaporation-condensation process of seawater inside the biosphere, as well as renewable energy harnessed from the sun. It does not require additional energy sources, as the microclimate and thermal state within the biospheres are ideal for the growth and production of the crop, thus making Nemo's Garden a self-sustainable system. It aims to make underwater farming an alternative, economically viable, eco-friendly, and self-sustainable agricultural system that thrive in adverse environmental condition and that will helps to revolutionize crop production. Fabbrocino (2020).

Eco-friendly: For plants growing inside the underwater farm, the need and maintenance are very minimal and it utilizes naturally-occurring circumstances (high thermal capacity of the sea) which allow the pod to maintain a stable and mild temperature Smart (2019b). Moreover, due to less interaction between the surrounding marine environment and related ecosystems the underwater farm poses no threat.Furthermore, it provides for a positive shelter-like effect and its presence has supported the repopulation of the surrounding marine areas. Also, there is a minimum possibility of leaking chemical fertilizers or pesticides into the soil and then into river water and groundwater, unlike in the case of conventional agriculture.

Improved yield, flavor, and nutritional qualities: According to Pistellia *et al.*(2020b), there were no detectable differences between the terrestrial and biospheres samples during micro-morphological analyses but physiological investigation shows that the concentration of total chlorophyll, total carotenoids, and total polyphenols was higher in plants grown in the biosphere as compared to terrestrial grown. While antioxidant activity and polyphenols contents were 31.52% and 13.3% respectively higher in biospheres samples compared to the terrestrial sample. In addition, there was the conversion of the essential oil chemotype from methyl eugenol/linalool to methyl eugenol

Challenges That Could Occur in the Nemo's Garden

1. Very expensive to set up, vulnerable to power and internet system failure and requires constant monitoring and maintenance, demands technical expertise
2. Production is limited compared to field conditions
3. Vulnerableto possible major natural disasters such as storm damage, tsunami, etc

Conclusion

The present agriculture practices are heavily mechanized, water and input-intensive. The adoption of unsustainable management practices is the root source of deterioration of the ecosystem, loss of biodiversity, water pollution, greenhouse gas emissions, and land degradation Karimi (2018). To overcome these challenges and make the best of the limited resources, there is a need for resource-efficient and self-sustainable agricultural models. Nemo's Garden ensures an alternative system in areas where practicing agriculture is unfeasible or complex. Underwater farming acts as an alternative to

conventional farming and it provides a new environment for plants to grow. Thanks to the constant temperature, high humidity, evaporation, and condensation that take place inside the pod, desalinized water are obtained and it can be used for irrigation of plants. Also, there is an abundance of space inside the pod with stable temperature and the environment is protected from pests that might damage crops. Research is in progress and more than a hundred different plant species including culinary herbs, like basil, oregano, strawberries, tomatoes, courgettes, beans, mushrooms, aloe Vera, lettuce, stevia, marjoram, thyme, lemon balm, orchids, etc have been successfully grown in Nemo's Garden using hydroponic techniques Gamberini (2021).

References

Aydinalp, C. and Cresser, M.S. 2008. The Effects of Global Climate Change on Agriculture. American-Eurasian *J. Agric. & Environ. Sci.* 3 (5): 672-676

Dini, G., Princi, E., Gamberini, S. and Gamberini, L. 2016. Nemo's Garden: Growing plants underwater. OCEANS 2016 MTS/IEEE Monterey, pp. 1-6

Pistelli, L., Guido Flamini, Roberta Ascrizzi, Laura Pistelli, Claudia Giuliani, Claudio Cervelli, Barbara Ruffoni, Elisabetta Princi, Sergio Gamberini, Luca Gamberini, Gianni Fontanesi, 2016. Preliminary results on basil grown in the Nemo's Garden. *Conference: 9th Joint Natural Products Conference. At: Copenhagen, Denmark.*

Pistellia, L., Roberta Ascrizzic, Claudia Giulianid, Claudio Cervellie, Barbara Ruffonie, Elisabetta Princif, Gianni Fontanesif, Guido Flaminib and Luisa Pistelli, 2020a. Growing basil in the underwater biospheres of Nemo's Garden: Phyto chemical, physiological and micromorphological analyses. *Scientia Horticulturae*. 259 : 108851.

Pistellia, L., Roberta Ascrizzic, Claudia Giulianid, Claudio Cervellie, Barbara Ruffonie, Elisabetta Princif, Gianni Fontanesif, Guido Flaminib, Luisa Pistelli 2020b. Growing basil in the underwater biospheres of Nemo's Garden: Phytochemical, physiological and micromorphological analyses. *Scientia Horticulturae.* 259: 108851

Smart, J. 2019a. Nemo's Garden. Ocean Geographic Society. Retrieved on 5 December 2021. https://www.ogsociety.org/journal/featured-articles/335-nemos-garden.html.

Smart, J. 2019b. Nemo's Garden. Ocean Geographic Society. Retrieved on 5 December 2021. https://www.ogsociety.org/journal/featured-articles/335-nemos-garden.html.

Karimi, V., Karami, E. and Keshavarz, M. 2018. Climate change and agriculture: impacts and adaptive responses in Iran. *J. Integr. Agric.* 3119(17): 61794-5.

McClatchie, C. A 2022. Produce Garden Flourishes Beneath the Ligurian Sea.Modernfarmer.Retrived on February 23: 2022. https://modernfarmer.com/2022/02/underwater-produce-garden/.

Nemo's Garden". Nemo's Garden. Retrieved on 10 November 2021. http://www.nemosgarden.com/

Fabbrocino, F. 2021. Basil and strawberries growing underwater: future farming and the case of Nemo's Garden. Lampoon Issue 24.

Seeley, D. How Siemens Is Helping an Italian Startup Enable Undersea Greenhouses. Dallasinnovates. Retrived on April 7, 2022. https://dallasinnovates.com/underwater-farming-how-a-plano-company-is-helping-an-italian-startup-enable-sub-aqua-greenhouses/.

Gamberini, S. 2021. We Created The World's First Underwater Garden. Retrieved on 22 April 2021. https://www.newsweek.com/we-created-world-first-underwater-garden-1611721.