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كلية الآداب والعلوم
College of Arts and Sciences
QATAR UNIVERSITY جامعة قطر

Algae-based biofertilizer for date palm cultivation in Qatar

Rihab Rasheed, Touria Bounnit, Hareb Al Jabri, Imen Saadaoui*
Algal Technologies Program, Centre for Sustainable Development, College of Arts and Sciences, Qatar University,P.O. Box 2713, Doha, Qatar.

Abstract

Date palm (*Phoenix dactylifera* L.) is a plant naturally adapted to the desert environment, it is producing a variety of dates with high nutritional value and preventing the desertification. However, the conventional way of date palm cultivation depends on the use of chemical fertilizer which is very harmful to the environment and human health. The current research project is targeting the use of local microalgae *Tetraselmis* isolate to substitute the conventional fertilizer for cultivating date palm (*Phoemix dactylifera cv. shishi*) plantlets during the acclimatization step to increase its viability, and growth while improving the soil quality. Therefore, the soil was supplemented with different concentrations of algae biomass, and thereafter the plant growth experiment continued for 3 months. Our results showed that 0.5 g of algal biomass not only substituted the conventional fertilizer but it also led to higher plant growth manifested by 100% survival rate, high ability of rooting (3.17 ± 0.14 roots), higher number of leaves (2.5 ± 0.25 leaves), longer shoot (33.75 ± 1.56 cm) and high amount of total chlorophyll (159.61 ± 9.6 mg L-1)..

Objective

The present work focuses on the use of local algae biomass, *Tetraselmis* isolate, as biofertilizer for cultivating date palm (*Phoenix dactylifera cv. shishi*) plantlets issued from in vitro culture during the acclimatization process, to increase its viability, growth and improve the soil quality.

Introduction

Date palm (*Phoenix dactylifera*) is the oldest fruit crops grown in the arid regions. It is considered as characteristic of the Gulf Cooperation Council Countries (GCC) and is playing a key role in the control of the desertification. In addition to that, dates fruits present high nutritional value and have great spiritual and cultural significance to the local people[1]. The generation time of the date palm is very long that's why the "in vitro" propagation through tissue culture emerged as a powerful tool for a rapid large-scale production.

During the acclimatization process, the conventional way of date palm cultivation depends on the use of chemical fertilizer which is very harmful to the environment and human health. Therefore, biofertilizers represent a very promising alternative leading to a sustainable agriculture.

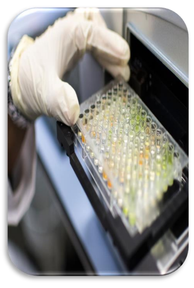
Algae represents a very promising alternative organic source of biofertilizer : (i) grow in arid areas [2], (ii) produce the majority of micro and macro nutrients necessary for plant growth and increase nutrient transfer, (iii) increase beneficial microorganisms in the soil [3], (iv) stabilize the soil aggregates, (v) mitigate the atmospheric CO2 leading to reducing greenhouse gasses and protect from climate change, reclaim the nitrogen and phosphorous from the waste and redirect it for supporting the organic agriculture [4].

The current research project is targeting the use of local microalgae *Tetraselmis* isolate to substitute the conventional fertilizer for cultivating date palm (*Phoemix dactylifera cv. shishi*) plantlets during the acclimatization step to increase its viability, and growth while improving the soil quality.

Methodology

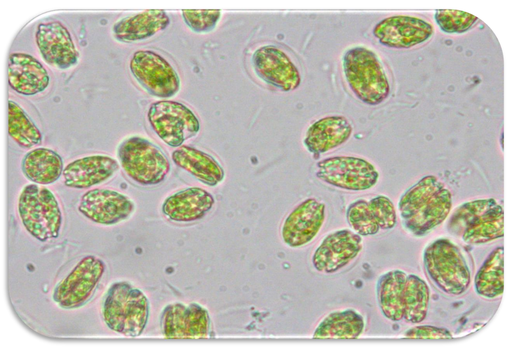
Algae isolation and production → Date palm plantlet treatment → Study of the effect of algae biobased fertilizer




Results & Discussion

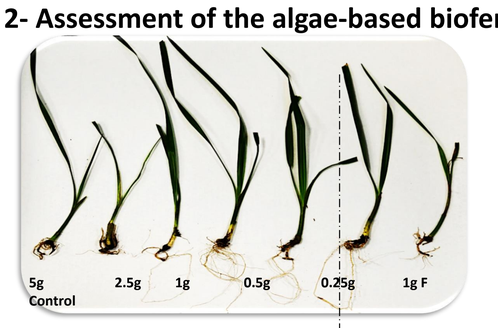
1- Algae isolation and Characterization



- 18SrDNA sequence proved that this strain is belonging to the genus of Tetraselmis (Figure 1).
- QUCCCM8 showed fast growth rate (0.48 d−1), good biomass productivity 81.4 mg L-1 d-1 and tolerance to high salinity and temperature (Das et al., 2016). On the other hand,
- Nitrogen (N), phosphorous (P), magnesium (Mg) and Potassium (K) with respective concentrations of 34; 5.4; 1.92 and 5.21 mg g-1 of biomass.

Figure 1: Morphological Study of the QUCCCM8 isolate via Light Microscopy, 40x magnification

2- Assessment of the algae-based biofertilizer on the growth



- 2.5 g and 5 g of algae led to slow growth and very low rooting expressed by number of roots equal to 1.33 and 1.25 roots, respectively.
- Low concentrations of algae such as: 0.25 g and 0.5 g led to the highest plantlets growth.

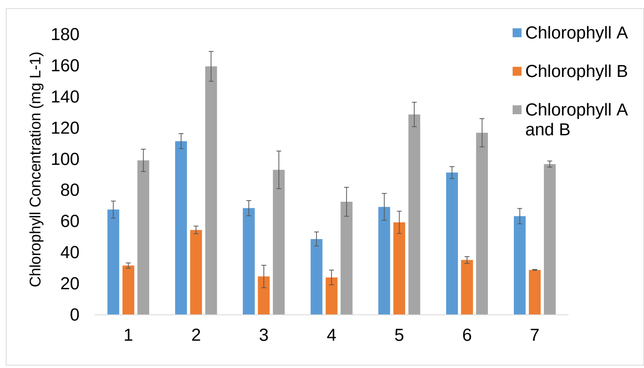
Figure 2: Date palm plantlets growth under different algae concentrations

Table 1: Growth parameters of the date palm after culture using different algae concentration

Treatment	Survival percentage (%)	Number of leaves	Number of roots	Shoot length (cm)	Stem Thickness (cm)
Control	97.66 ± 1.52	3 ± 0.66	1.75 ± 0	31.33 ± 3.82	5.92 ± 0.14
Fertilizer	97.33 ± 0.57	2.25 ± 0.86	1.5 ± 0.43	27.25 ± 9.21	5.42 ± 2.36
0.25 Algae	100 ± 0	3 ± 0	1.83 ± 0.28	34.42 ± 3.61	7.92 ± 0.87
0.5 Algae	**100 ± 0**	**3.17 ± 0.14**	**2.5 ± 0.25**	**33.75 ± 1.56**	**9 ± 0**
1.0 Algae	98.66 ±1.15	3.05 ± 0.72	2.08 ± 0.14	31.83 ± 2.80	7.75 ± 0.25
2.5 Algae	95.66 ± 1.15	1.92 ± 0.62	1.33 ± 0	24.83 ± 7.42	5.42 ± 1.04
5 Algae	96.33 ± 1.15	1.83 ± 0.52	1.25 ± 0	26.42 ± 4.16	5.25 ± 0.25

Study of the growth parameters showed that 0.5g algae was the best conditions leading to the highest number of roots (2.5 ± 0.25), highest number of leaves (3.17 ± 0.14) and highest stem thickness of 9 cm.

3- Effect of the algae-based biofertilizer on the Photosynthetic pigments



- The plantlets cultivated using 0.5 g of algae presented the highest total Chlorophyll amount of 159.61 ± 9.6 mg L-1. This confirmed that 0.5 g of algae is the best condition leading to the best date palm plant growth.

Figure 3: Chlorophyll concentration of the date palm plants
Conditions: **1**: 0.25g Algae; **2:** 0. 5g Algae; **3:** 1 g Algae; **4:** 2.5 g Algae; **5:** 5 g algae; **6:** 1g fertilizer and **7:** control (without fertilizer and algae)

4- Determination of the soil quality after treatment with different algae concentrations used as biofertilizer

Table 2: Soils element properties from different algae treatments.

Conditions	Ca (ug g^{-1} soil)	K (ug g^{-1} soil)	Mg (ug g^{-1} soil)	Na (ug g^{-1} soil)	Total nitrogen (ug g-1 soil)	Phosphorous (ug g-1 soil)
0.25 g algae	267.99±1.9	99.8 ± 3.2	559.62± 45.9	209.7± 11.7	4.8 ± 1.3	41.25±16.03
0.5 g algae	248.6±16.6	121.59 ± 40	451.35± 23.4	212.47±17.9	10.095± 5.8	49.91 ± 3.37
1 g algae	289.45±38	96.03 ± 6.7	427.2 ± 133	189.83±0.37	5.185±1.01	42.96 ± 13.4
2.5 g algae	289.5±33.5	76.22 ± 0.5	560.59±39	202.32±2.16	7.34±0.35	56.25 ± 9.8
5 g algae	265.80±16	72.89 ± 5.62	516.74± 25.9	208.63±13.7	8.455 ± 0.45	55.47 ± 1.1
1g fertilizer	263.80±16	71.41 ± 5.8	552.59±19	226.98±14.3	2.43±0.08	34.89 ± 6.04

The comparative analysis of the heavy metal content in the soil showed high similarity between the samples containing different algae concentrations and the control suggesting that microalgae as a fertilizer did not increase or introduce heavy metals to the soil

Table 3: Heavy metal composition of the soils amended with the different algae concentrations.

Condition	Fe (ppm)	B (ppm)	Ba (ppm)	Cd (ppm)	Co (ppm)	Cr (ppm)	Mn (ppm)	Mo (ppm)	Ni (ppm)	Pb (ppm)	Sr (ppm)	V (ppm)
0.25g Algae	321.28 ±2.1	1083.53±8.7	3.2±0.009	0.036±0	0.46±0.007	6.71±0.62	6.33±0.01	0.09±0.001	4.72±0.2	0.27±0.02	2.12±0.23	0.58±0.05
0.5g algae	266.65 ±4.04	1048.89±18	4.04±1.47	0.03±0.007	0.38±0.009	5.62±0.41	4.99±0.02	0.10±0.007	3.67±0.29	0.32±0.01	1.86±0.28	0.47±0.02
1g Algae	253.20 ±74.8	1015.73±18	3.05±0.15	0.02±0.006	0.37±0.08	5.35±1.9	4.87±1.35	0.1±0.001	3.56±1.01	0.29±0.01	3.09±0.63	0.46±0.10
2.5g Algae	334.39 ±18.75	1081.76±22	2.64±0.05	0.037±0.002	0.45±0.01	7.06±0.1	6.18±0.15	0.104±0.002	4.54±0.07	0.25±0.02	4.83±0.8	0.56±0.01
5g Algae	315.72 ±31.9	1081.92±12	2.55±0.19	0.033±0.001	0.44±0.03	6.63±0.6	6.12±0.69	0.108±0.003	4.28±0.24	0.29±0.02	5.73±0.55	0.58±0.08
1g Fetilizer	324.46 ±29.63	1045.38±2	2.92±0.28	0.03±0.003	0.47±0.01	6.93±0.37	6.74±0.48	0.10±0.002	4.48±0.28	0.28±0.03	1.66±0.04	0.66±0.12

Algae-based bio fertilizer can be considered as sustainable since it improved safely the chemical composition of the soil without contaminating it with especially toxic metals such as: As, Cd and Ni.

5- Microbiology Analysis of the soil samples

Condition	Total DNA extraction ug/ml
0.25 g algae	22.5
0.50 g algae	102.4
1 g algae	105.5
2.5 g algae	57.5
5 g algae	58.1
1 g fertilizer	64.2

The analysis of the DNA concentration from the different previous conditions showed that 0.5g and 1g of algae led to the highest DNA concentration. Hence, this soil is the richest on microorganisms which proves its highest quality.

Conclusion

- The use of Qatar microalgae isolate with different concentrations as biofertilizer was investigated for there first time on date palm plantlets issued from tissue culture.
- After 3 months of treatment, our results showed that 0.5 g of algae led to the highest plant growth, improved the elemental composition of the soil and maintained a safe low level of heavy metals amounts in the soil.
- The data generated from our work proved that the use of Microalgae (QUCCCM 8), as biofertilizer, is an environment-friendly which can be used as alternative to chemical fertilizers in propagating date palm trees without affecting the environment, and maintaining the soil quality.

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