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Effect of different water temperatures on growth of aquatic plants *Salvinia natans* and *Ceratophyllum demersum*

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ABSTRACT

Objective: To evaluate the effect of some different water temperatures on growth of aquatic plants (*Salvinia natans* and *Ceratophyllum demersum*).
Methods: The aquatic plants were brought from Shatt Al-Arab River in 2016. Equal weights of aquatic plants were aquacultured in aquaria, and were exposed to three different temperatures (12, 22 and 32 °C).
Results: The results showed that the two plants did not show significant differences with respect to their effects on pH and electrical conductivity values. Time and temperature did not affect the values of pH and electrical conductivity. The values of dissolved oxygen was significantly influenced with variation of time and temperature, while the two plants did not have significant differences on dissolved oxygen values, nitrate ion concentration and was not significantly influenced with variation of plant species or temperature or time. Plant species and temperature significantly affected phosphate ion concentration, while the time did not significantly influence the concentration of phosphate ion. Chlorophyll a content and biomass were significantly influenced with the variation of plant species, and temperature .
Conclusions: Aquatic plants has a species specific respond to temperatures change in their environment. Water plant, *Ceratophyllum demersum* is more tolerant to temperatures change than *Salvinia natans.*

1. Introduction

Water temperature affects plants in many ways. A change of temperature alters metabolic activity and even affects aquatic ecosystems. From house plants to aquatic plants, water temperature plays a part in growth and development. Water temperature affects the metabolic activity of plants, slowing activity under cool conditions[1]. All plant growth and development is influenced by temperature and plants vary regarding the temperature range in which they can grow[2,3]. It is well known that diurnal temperature fluctuations in water can be much less than on dry land but this is dependent on the volume of water[3].

The use of aquatic plants for remediation of aquatic ecosystems has received increasing attention. Many investigations have been conducted to proved the effectiveness of aquatic plants in remediation such as to remove heavy metal[4], arsenic[5], copper, nickle and zinc[6]. To achieve more effective function in managing such polluted aquatic ecosystem, choosing the most suitable aquatic plant species is significantly important. Several aquatic plant characters are used to test their effectiveness for remediation including oxygen production and consumption, growth or photosynthesis rate and salinity tolerance. The purpose of this research is to investigate the effects of temperature on two aquatic plants in order to determine the effectiveness of using this plant species for water managements, such as in producing oxygen, and pollution removal in aquatic ecosystem which has led to be used in aquacultures management.

2. Materials and methods

The aquatic plants [*Salvinia natans* (*S. natans*) and *Ceratophyllum demersum* (*C. demersum*)] were brought from Shatt Al-Arab River to the laboratory. They were washed to clean from the dirt and materials attached. Then, equal weights of aquatic plants *S. natans* and *C. demersum* were aquacultured in aquaria of the same sizes. The three different temperatures (12, 22 and 32 °C) were selected for the experiment. Water chemical and physical measurements, biomass, chlorophyll a content of the two plants were also done. The aquatic plants were checked using Iraq-specific references (*e.g.* Al-Sa'ady and Al-Mayah 1983)[7].

2.1. Culturing process

Two local species of aquatic plants, *S. natans* and *C. demersum* were cultured in 1-L glass containers. These containers contained

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cleaned dechlorenated tap water. Each species of the two plants in a set of four duplicated containers were adjusted for 12, 22 and 32 °C treatments. Sampling were carried out for physical, chemical analysis before and after the experiment.

2.2. Physical analyses

Temperature and electrical conductivity was measured by using Ysi apparatus , model 556.

2.3. Chemical analyses

The concentration of dissolved oxygen was measured according to Azide modification in Winkler, a method and described by Lind[8] and the product was expressed in mg/L, pH was measured by using Ysi apparatus, model 556. The phosphate were measured by the method that was described by Murphy and Riley[9]. The nitrate and nitrite ions were colorimetrically determined by using cadmium pole as it was mentioned in American Public Health Association[10].

At the end of the experiment chlorophyll a and biomass were measured, by taking 5 g of the aquatic plant and crushed by porcelain mortar with 10 mL of 90% acetone and was left in refrigerator for 24 h after surrounding the vials with aluminum foils, the filtrate was measured on 665 and 750 nanometer wavelengths, by using spectrophotometer (Hitachi type, 4-1500 model). After that two drops of 2 mol/L HCl were added to each sample, then the measurements of absorption were repeated using the same above mentioned wavelengths, according to Lorenzen, s equations (Vollenweider, 1971)[11]. F test was used to test the data.

3. Results

After 7 days of aquaculturing the two plants *S. natans* and *C. demersum* (Tables 1, 2), the highest value of nitrate (43.29) µg/L was in 32 °C aquarium of *C. demersum* and the least one 0.80 µg/L was in 12 °C aquarium of *S. natans*, while the highest value of nitrite (13.63) µg/L was in 32 °C aquarium of *C. demersum* and the least value of it (0.56) µg/L was in 12 °C aquarium of *S. natans*. The highest value of phosphate (6.53) mg/L was in 32 °C of *C. demersum* and the least value of it (1.47)mg/L was in 22 °C aquarium of *C. demersum*.

After 14 days of aquaculturing the two plants *S. natans* and *C. demersum*, (Tables 3, 4) the highest value of nitrate (4.34) µg/L was in 22 °C aquarium of *C. demersum* and the least value of it (1.62) µg/L in 12 °C of *S. natans*, while for the nitrite the highest value of nitrite (13.13) was in 22 °C aquarium of *C. demersum* and the least value of it (4.50) µg/L was in 12 °C aquarium of *S. natans*, while for phosphate the highest value of phosphate (6.60) mg/L was in 12 °C of *C. demersum* and the least value of it (1.58) mg/L was in 22 °C aquarium of *S. natans*. After finishing the experiment that lasted fourteen days, *S. natans* was more efficient than *C. demersum*, because the aquaria that contained *S. natans* at 12 °C and 22 °C showed nitrate, nitrite and phosphate values less than the ones of *C. demersum* aquaria.

Significant differences were not found between the two the plants with respect to their effects on pH and electrical conductivity values. Time and temperature did not affect the pH and electrical conductivity. The values of dissolved oxygen was significantly influenced with time and temperature differences, while the plants did not have significant differences on dissolved oxygen values. Nitrate ion concentration was not significantly influenced with plant or temperature or time or variation. Plant species and temperature significantly influenced phosphate ion concentration, while the time did not significantly influence the concentration of phosphate ion.

Table 1
Physicochemical characteristics of water media that were used for aquaculturing of aquatic plants after seven days .

Aquatic plant	Temperatue (°C)	Electrical conductivity (ms)	pH	Dissolved oxygen (mg/L)
S. natans	12	3.1	5.8	10.5
C. demersum		3.0	4.7	10.3
S. natans	22	3.0	5.5	5.3
C. demersum		2.9	5.5	4.5
S. natans	32	4.4	5.4	4.3
C. demersum		5.5	5.8	4.8

Table 2
Water physicochemical characteristics of water media that were used for aquaculturing of aquatic plants after seven days .

Aquatic plant	Temperature (°C)	NO_3 (µg/L)	NO_2 (µg/L)	PO_4 (mg/L)
S. natans	12	0.80	0.56	5.31
C. demersum		6.17	2.19	5.09
S. natans	22	7.64	2.65	2.90
C. demersum		13.40	4.42	1.47
S. natans	32	11.14	3.73	1.64
C. demersum		43.29	13.63	6.53

Table 3
Physicochemical characteristics of water media that were used for aquaculturing of aquatic plants after fourteen days .

Aquatic plant	Temperature (°C)	Electrical conductivity	pH	Dissolved oxygen (mg/L)
S. natans	12	3	4.8	7.5
C. demersum		3	4.6	7.7
S. natans	22	3	5.3	4.5
C. demersum		3	5.3	4.7

Table 4
Water physicochemical characteristics of water media that were used for aquaculturing of aquatic plants after fourteen days.

Aquatic plant	Temperature (°C)	NO_3 (µg/L)	NO_2 (µg/L)	PO_4 (mg/L)
S. natans	12	1.62	4.50	3.90
C. demersum		4.31	13.03	6.60
S. natans	22	3.74	11.35	1.58
C. demersum		4.34	13.13	3.90

The chlorophyll a contents and biomass of aquatic plants, *S. natans* and *C. demersum* were shown in Figures 1, 2. *S. natans* produced chlorophyll a and biomass contents in 12 and 22 °C aquaria in amounts higher than those of *C. demersum*, but 32 °C was more suitable for both aquatic plants. The content of chlorophyll a and biomass for the two aquatic plants were significantly influenced with the variation of time, plant species and water temperatures.

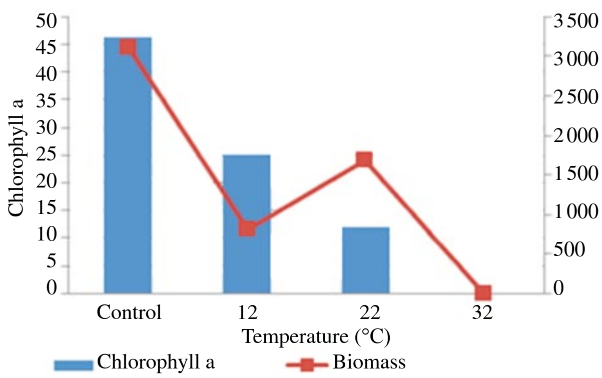

Figure 1. Variation of the chlorophyll a content and biomass of *S. natans*.

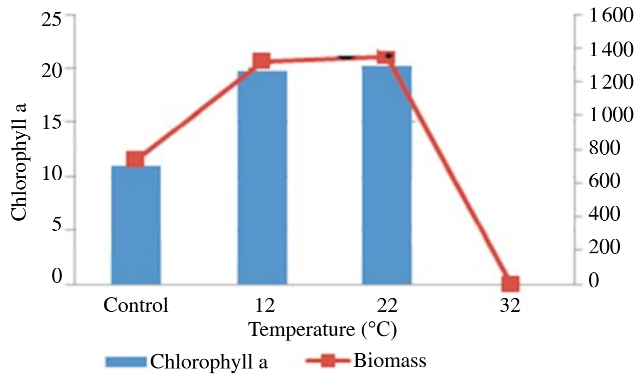

Figure 2. Variation of the chlorophyll a content and biomass of *C. demersum*.

4. Discussion

Chlorophyll a concentration is an indicator of phytoplankton abundance and biomass in coastal and estuarine waters. They can be an effective measure of trophic status[12], and potential indicators of maximum photosynthetic rate (P-max)[13] and are a commonly used measure of water quality. High levels of chlorophyll a concentration often indicate poor water quality and low levels often suggest good conditions. However, elevated chlorophyll a concentrations are not necessarily a bad thing. It is the long-term persistence of elevated levels that is a problem. For this reason, annual median chlorophyll a concentrations in a waterway are an important indicator in State of the Environment[14]. It is natural for chlorophyll a levels to fluctuate over time. Chlorophyll a concentrations are often higher after rainfall, particularly if the rain has flushed nutrients into the water. Higher chlorophyll a levels are also common during the summer months when water temperatures and light levels[15].

In aquatic ecosystems, native, submerged macrophytes may produce more biomass in highlight availability conditions compared with non-native species[16] and in contrast, climatic change is able to modify environmental conditions, resulting in community restructure[17], and both native and non-native species may alter their response to such condition[18]. Environmental conditions also affect biotic interactions, including competition[19]. The competition between native and non-native species. For example, temperature increase and nutrient loading favor non-native species, which then limit native species in European aquatic systems, which suggests that global warming can increase non-native dominance[20]. Moreover, with rising temperatures, the growth rate of invasive species may increase at twice the rate of native species[21].

Conflict of interest statement

We declare that we have no conflict of interest.

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