The growth rate and chlorophyll content of water hyacinth under different type of water sources

A A Hasibuan, R Yuniati and W Wardhana
Department of Biology, Faculty of Mathematics and Natural Sciences (FMIPA), Universitas Indonesia, Depok 16424, Indonesia
Corresponding author’s email: ratnayuniati@sci.ui.ac.id

Abstract. Agathis Lake is one of the six lakes around Universitas Indonesia, Depok. This lake is a water body whose water quality has been damaged due to pollution from domestic and industrial waste around Beji area, Depok. Water hyacinth (Eichhornia crassipes (Mart.) Solms.) is a plant that has the ability to absorb contaminants in aquatic environment. This study was designed to determine the growth rate and chlorophyll content of water hyacinth under different type of water sources as growing media. These two physiological parameters are used to determine whether the contaminants contained in the Lake Agathis interfere the growth of water hyacinth. The research was conducted at the greenhouse of Department of Biology, FMIPA, Universitas Indonesia for six days, after 1-week acclimatization by culturing water hyacinth in 30 L capacity plastic tanks. Sixteen plants of water hyacinth, each of approximately 28–31 g wet weight, were placed into four plastic tanks. Two tanks filled with 10 L tap water, and another two filled with 10 L lake water (Agathis Lake). The results showed that the Relative Growth Rate (RGR) of water hyacinth in the tap water was higher than the lake water. The chlorophyll content of water hyacinth cultured in the lake water was higher than the plant cultured in tap water.

Keywords: Chlorophyll, relative growth rate, water hyacinth, lake agathis

1. Introduction
Water hyacinth (Eichhornia crassipes) is one of the aquatic plants that has rapid rate of growth and so are regarded as weed. The rapid growth of water hyacinth resulted in low dissolved oxygen in water and it can cover large areas of water bodies [1]. Besides the negative effect, water hyacinth has several benefits such as absorbing heavy metals, providing livestock feed, and its fiber can be used to make handicrafts [2].

Due to the ability to absorb heavy metals, water hyacinth can get poisoned because of the binding of element on heavy metals to cell enzyme, thus inhibiting the enzymes that regulate the process of respiration, photosynthesis, and growth. Several studies show that heavy metals such as Cd and Cu cause the reductions in growth [3].

Water hyacinth also has the ability to absorb contaminants in the aquatic environment. This can have an impact on morphological and physiological characteristics. Different environment can lead to the different morphological and physiological characters of water hyacinth. Also, it is not yet known whether this ability affects the physiology of water hyacinth. Agathis Lake is one of the six lakes around Universitas Indonesia, Depok. This lake is a water body whose the water quality has been damaged due
to pollution from domestic and industrial waste around Beji area, Depok. This study was designed to determine the growth rate and chlorophyll content of water hyacinth under different type of water sources as growing media. These two physiological parameters are used to determine whether the contaminants contained in Lake Agathis interfere the growth of water hyacinth.

2. Methodology

2.1. Plant and experimental design
Water hyacinth of similar size was collected from Jannati Firdaus Farm, Sawangan, Depok. The research was conducted at the Greenhouse of Department of Biology, FMIPA, Universitas Indonesia for six days. The collected plant which amounted sixteen plants of water hyacinth were placed into four plastic tanks filled with tap water for acclimatization. After acclimatization for 7 days, water hyacinth was put into two plastic tanks filled with 10 L tap water and two plastic tanks filled with 10 L lake water. Environmental parameters such as temperature and pH were observed every day. After the experiment was over, the water hyacinth sample was taken to the physiology laboratory to measure its chlorophyll content.

2.2. Relative Growth Rate
Relative Growth Rate of plants was measured on day 2, day 4, and day 6 during the experiment. Relative Growth Rate (RGR) was determined using the following equation 1,

\[ RGR = \frac{\ln W2 - \ln W1}{t} \times 100\% \]  

where, \( W1 \) is the mean initial fresh weight, \( W2 \) is the fresh weight in the final status and \( t \) is the time interval (the experiment period) [4].

2.3. Chlorophyll content
Chlorophyll a, chlorophyll b, and total chlorophyll were measured in the leaves of water hyacinth. Leaves of water hyacinth from tap water and lake water were grinded using mortar by adding 85% acetone as a solvent. Then, the solution was filtered using Whatman Filter No. 1. The filtrate was then added with the same solvent until it becomes 25 mL. After that, the obtained solution was measured for its absorbance using a spectrophotometer. Chlorophyll a was read at wavelength 645 nm and wavelength 663 nm for chlorophyll b [5]. Total chlorophyll was determined using the following equation 2 [6],

Chlorophyll a = 12.7 D663-2.69 D645 (mg/L)

Chlorophyll b = 22.9 D645 - 4.68 D663 (mg/L)  

Total chlorophyll = 20.2 D645+8.02 D663 (mg/L)  

2.4. Nutrient content in Lake Agathis
Nutrient testing was carried out at Laboratorium Penguji Balai Penelitian Tanaman Rempah dan Obat (Balitro), Cimanggu, Bogor, 16111, Indonesia. Water from Lake Agathis and tap water were both tested. The tested water sample was 600 mL.

3. Results and discussion
In the table 1, it can be seen that during acclimatization the environmental parameters did not change significantly. Range of water temperature during the acclimatization is 28–30 °C, environmental
temperature is 33–34 °C, humidity from 44–55 %, stable pH at 5, and range of light intensity is 507–645 cd.

From table 2, it can be seen that there is a different pH between lake water and tap water. pH of lake water is 7 while pH of tap water is 6. Water temperature of the lake water ranges from 28–29 °C while tap water is 27–29 °C. Based on the literatures, water hyacinth has an ideal growing condition i.e. water temperature below 34 °C, environmental temperature above 0 °C [7].

In the table 3 and figure 1, it can be seen that water hyacinth grown in tap water has a higher RGR value compared to the one in lake water. In day 2, both water hyacinth which is grown in tap water and lake water have the same value of RGR. But, when entering the day 3, water hyacinth grown in tap water has a higher RGR compared to the lake water. Likewise, for the day 6.

In the table 4, the total chlorophyll is higher in water hyacinth grown in the lake water. Total chlorophyll content and chlorophyll a/b ratio are often used as indicators of stress in plants and also parameters for photosynthetic activity [8].

As shown in the table 5, lake water contains higher values of P, Na, Ca, Mg, C-organic than tap water. But, in tap water, Fe, Zn, and Co are detected, while in lake water they are not detected. When nutrient availability increases, some species have the ability to increase their growth [9].

Table 1. Environmental parameters during acclimatization.

| Date          | Water temperature | Environment temperature | Humidity | pH | Light intensity |
|---------------|-------------------|-------------------------|----------|----|----------------|
| 27 June 2019  | 30 °C             | 34 °C                   | 45 %     | 5  | 645 cd         |
| 28 June 2019  | 28 °C             | 34 °C                   | 44 %     | 5  | 545 cd         |
| 29 June 2019  | 28 °C             | 34 °C                   | 49 %     | 5  | 539 cd         |
| 1 July 2019   | 29 °C             | 33 °C                   | 51 %     | 5  | 534 cd         |
| 2 July 2019   | 28 °C             | 33 °C                   | 55 %     | 5  | 507 cd         |
| 3 July 2019   | 29 °C             | 38 °C                   | 54 %     | 5  | 540 cd         |

Table 2. Environmental parameters during experiment.

| Day | Lake water | Tap water |
|-----|------------|-----------|
|     | Water temperature | pH | Water temperature | pH |
| 1   | 28 °C       | 7   | 27 °C       | 6  |
| 2   | 28 °C       | 7   | 28 °C       | 6  |
| 3   | 28 °C       | 7   | 28 °C       | 6  |
| 4   | 29 °C       | 7   | 29 °C       | 6  |
| 5   | 29 °C       | 7   | 29 °C       | 6  |
| 6   | 28 °C       | 7   | 28 °C       | 6  |

Table 3. Relative growth rate of water hyacinth.

| Day | Lake water | Tap water |
|-----|------------|-----------|
|     | Relative growth rate (g.day⁻¹) |          |
| 2   | 0.011      | 0.011     |
| 4   | 0.011      | 0.037     |
| 6   | 0.037      | 0.059     |
Figure 1. Relative growth rate of water hyacinth.

Table 4. Chlorophyll content

|                | Chlorophyll a | Chlorophyll b | Total chlorophyll |
|----------------|---------------|---------------|-------------------|
| Lake water     | 1.143         | 0.608         | 1.751             |
| Tap water      | 0.914         | 0.385         | 1.300             |

Table 5. Nutrient content

|          | Lake water | Tap water |
|----------|------------|-----------|
| N (%)    | 0.011      | 0.014     |
| P (ppm)  | 20.43      | 11.00     |
| K (ppm)  | 2.70       | 3.79      |
| Na (ppm) | 43.82      | 21.50     |
| Ca (ppm) | 45.72      | 27.38     |
| Mg (ppm) | 10.44      | 8.78      |
| C-org (%)| 0.10       | 0.01      |
| Fe (ppm) | 5.25       | 2.44      |
| Cu (ppm) | Not detected | Not detected |
| Mn (ppm) | Not detected | Not detected |
| Zn (ppm) | Not detected | Not detected |
| Pb (ppm) | Not detected | Not detected |
| Cd (ppm) | Not detected | Not detected |
| Co (ppm) | Not detected | 0.60      |

The result showed that different environmental condition will produce a different physiological character. Relative Growth Rate of water hyacinth has a higher value when it grows in tap water. It can happen because in tap water there are macronutrients i.e. Fe, Zn and Co, on the contrary to lake water.
where Fe, Zn and Co are not detected. Iron (Fe) is important for plant because Fe plays a role in cellular processes and also is necessary for plant growth and productivity. In plant, Fe are in the center of on chloroplast, mitochondria and vacuoles. Zinc (Zn) has several functions such as it is important for carbohydrate metabolism, protein metabolism, auxin and pollen formation in plants. Zn is also able to control biological membranes and performs a defence mechanism against the harmful pathogens. Cobalt (Co) also plays an important role for the plant growth and biochemical processes in plant. But, if the amount is too high it will cause toxicity [10]. Plant with high growth rates are indicated to have a good ability to mobilize and store nutrients in the tissues and assimilate the large amounts of carbon dioxide (CO2) [11]. During the study, the water temperature also supports the water hyacinth growth. Previous study showed that water hyacinth RGR is increased when nutrient and temperature is increased. Those results showed a positive correlation between nutrient and temperature in water [9].

Chlorophyll refers to the green pigment found in plants, algae, and photosynthetic bacteria. Chlorophyll in plant takes an important part in the process of photosynthesis in which chlorophyll will absorb the light and convert it into chemical energy. Chlorophyll contain chloroplasts. Chloroplasts is an organelle in a plant cell which has a double membrane. Higher plants have two kinds of chlorophyll, namely chlorophyll a and chlorophyll b [12].

Based on the result, chlorophyll content in leaves of water hyacinth which grown in lake water has a higher value compared with tap water. Nutrient test resulted that Co is detected in tap water which makes the total chlorophyll decreases. Heavy metals such as Co can inhibit some enzymes that play a role in metabolic processes, and this is the main cause of chlorophyll degradation. Decrease in chlorophyll content is also a sign that plant is under stress. These results are confirmed by visual characteristics of the plant i.e. yellowing on leaves (figure 2). One study also proves that total chlorophyll content decreases when plant is exposed to Co [13].

High chlorophyll content in water hyacinth grown in lake water is a plant response to water stress. A few studies have been conducted in this regards. Water stress makes chlorophyll content decrease and this is reported in mung bean. But, some studies show the opposite where the chlorophyll content actually increases during water stress [14]. A difference in results indicates that the effect of drought and water stress on plant chlorophyll content depends on the plant genotype and several other factors [15].

4. Conclusion
The result of this study indicates that different type of water sources affect the physiological characters of water hyacinth. The results show that the Relative Growth Rate (RGR) of water hyacinth in the tap water was higher than the lake water. The chlorophyll content of water hyacinth cultured in the lake

Figure 2. Yellowing on leaves of water hyacinth.
water was higher than plant cultured in tap water. The difference of physiological characters is due to the nutrient content in lake water and tap water. These results also show that contaminants in Lake Agathis interfere the growth of water hyacinth. The ability of water hyacinth to absorb heavy metals and pollutants has been proven in several studies. But, apparently it has an impact on the physiology of water hyacinth. When physiology is disturbed, it is feared that it will have a negative effect to water hyacinth, such as reducing the ability to absorb heavy metals.

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