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MINERAL BALANCE OF AN INVASIVE ALGA *CAULERPA RACEMOSA* VAR. *CYLINDRACEA* ON THE COAST WEST OF ALGERIA

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Abstract

Our study was based on the demonstration of the water contents, of Chlorophylls a, Chlorophyll b, and Carotenoids, and of the mineral elements Na^+, K^+, Mg^{2+}, Ca^{2+}, in the thalli of the invasive alga *Caulerpa racemosa* var *cylindracea* harvested in eight stations located on the west coast of Algeria positioned on the Wilaya of AIN TEMOUCHANT; Sbiaat, the wilaya of ORAN; Bousfer, Kristel, Arzew, Mers el hadjadj, and the wilaya of MOSTAGANEM; Stidia, Salamander and Grove. The results obtained indicate a high water content for our thalli and high pigments contents compared for the stations studied, and significant contents in nutrients Na, Mg for the thalli from the different study sites marking a lack of element K by Na ratio by studying the Na / K ratio and a Ca level which is within the norms, which leads us to conclude that our species is rich in essential elements for its well being.

Key word s: *Caulerpa racemosa* Var *cylindracea*, mineral elements, Chlorophyll a, Chlorophyll b, Carotenoids, Algeria.

Introduction

Algae are unicellular or multicellular eukaryotic organisms (Pereira & Neto 2015), presenting a great diversity (Stengel & Connan 2015), according to their size, they can be divided into microalgae and macroalgae, which also include green, brown and red algae according to pigmentation (Qin 2018). The three groups presented by different pigmentations are photosynthetic from the Plantae kingdom (Pereira 2018) which is characterized by its rapid growth and a possibility of CO_2 fixation to ensure good photosynthesis (Chojnacka *et al* 2018). The green alga *Caulerpa racemosa* Var *cylindracea* is a green alga known for its biological activities (Kumar *et al*., 2011., Kumar & *et al*., 2019,), is one of the invasive species in the Mediterranean basin, it was reported for the first time in Algeria in the bay of Algiers in 2007 (Oueld-Ahmed & Meinesz, 2007) then on the west Algerian coast, precisely in the bay of Arzew, the stations of Salamandre and Stidia (Mostaganem, Algeria) in 2010 (Bachir Bouiadjra *et al*., 2010a, 2010b). Studies are looking at the spread of this invasive species on the Algerian coast. Our study is based on the identification of the content of chlorophylls a, b and carotenoids, and a study on the content of mineral elements Mg^{2+}, Ca^{2+}, K^+, and Na^+ which are necessary for the food and the well being of this species.

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Materials and Methods

Plant material

The plant material used during this study is a green alga: *Caulerpa racemosa* var *cylindracea*, harvested between December 2019 and March 2020 on the coasts of the regions of; Sbeaat wilaya of AIN TEMOUCHENT, Bousfer, Kristel, Arzew and Mers el Hadjaj wilaya of ORAN, and the regions of stidia, Salamander and Hadjadj (Bosquet) wilaya of MOSTAGANEM.

Choice of sites

Geographical identification of study stations

Wilaya : AIN TEMOUCHENT : Sbeaat Latitude N 35° 18' 26.1"Longitude E 1° 8' 32.825"

Fig. 1: Geographical location of the study stations (Google Earth, 2020).

Wilaya: ORAN : Bou sfer Latitude N35°43'36 Longitude E"0°51'0"

- Kristel Latitude N 35° 492 343 Longitude E 0° 292 003
- Arzew Latitude N 35°51'01" Longitude E 0°19'04"
- Mers el Hadjadj Latitude N 35° 472 003 Longitude E 0° 102 003

Wilaya : MOSTAGANEM : Stidia Latitude N 35° 502 003 Longitude E 0° 002 003

- Salamandre Latitude N 35° 562 003 Longitude E 0° 052 003
- Hadjaj (Bosquet) Latitude N36° 062 003 Longitude E 0° 202 003

Preparation of samples

In the laboratory, the harvested plant material was washed several times with tap water to remove excess salt, grains of sand, other algae and other particles. then weighed separately to have the fresh weight, then dried in the open air for a few days until having a dehydrated product, then put in the oven at 40°C for 24 hours to facilitate its grinding, or the measurement of the weight dry was established. The final product was ground using a mortar separately for each plant material collected in each station, as soon as it left the oven (to maintain its maximum dehydration). Finally, the powder obtained was kept in labeled pill boxes, put in the freezer until the day of extraction and dosage of the miner elements. We weighed apart a quantity of fresh material for the analysis of the chlorophyll a, b and carotenoid contents.

Parameters analyzed

The water content

The water content was identified using the following formula:

Water content% = Fresh weight - Dry weight / Fresh weight * 100

Estimation of pigments

We weighed 100 mg of fresh material from the thallus of *Caulerpa racemosa* from each station studied with four repetitions. Our plant material was ground in 10ml of 80% acetone and then stored cool at 4 ° C in the dark for 48 hours then read using the UV spectrophotometer to have the optical density at different wavelengths; 645, 663 et 480 nm. (Kirk & Allen, 1965)

Chlorophyll a (mg/g for wt.) = 12.7× A663 – 2.69×A645

Chlorophyll 'b' (mg/g for wf) = 22.9 × A645 – 4.68 × A 663

Carotenoid (mg/g for wf) = 4 × (A480) × 10 / 500

The mineral content

The method used was acid attack according to Vogel-Milkus & *et al.*, (2005); 60 mg of the vegetable powder of each sample are dissolved in 7 ml of mixture (HNO_3 / $HClO_4$) (7V / 1V), incubated in the dark for 24 hours

then diluted in 10 ml of 0.2% HNO_3 and then read at using an atomic absorption spectrophotometer

Statistical analysis

The results were analyzed statistically using the Statistica 6 software. Analysis of variance (ANOVA) was used to test that the means of measured outcomes. Fisher's Least Significant Differences (LSD) was used to compare pairs of mean at ±=0.05.

Results

1. The water content

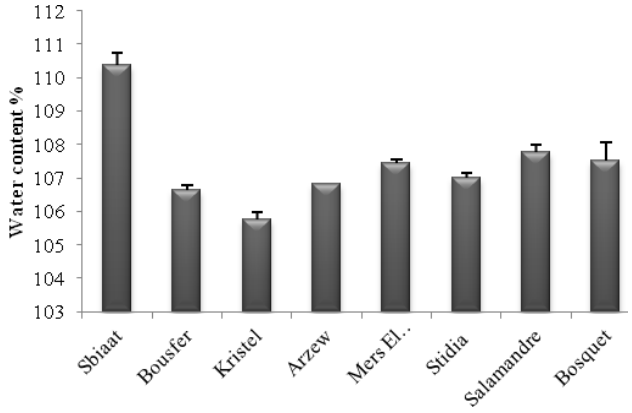

Fig. 2: Water content in the thalli of *Caulerpa racemosa* var *cylindracea* collected in the different stations studied.

The water content could record more or less important values for the thalli of *Caulerpa racemosa* harvested in all the study sites. It marked its minimum at Kristel station with the value 105.76 ± 0.2% and the maximum at the sbiaat station reaching a value of 110.36 ± 0.39%

2. Pigment content

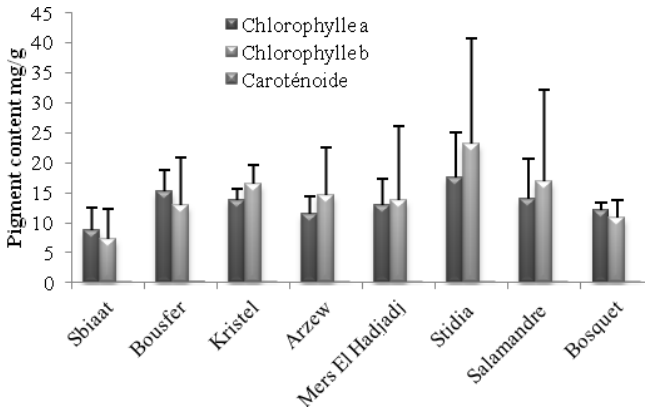

Fig. 3: Content of Chlorophyll a, Chlorophyll b, and, carotenoids in the thalli of *Caulerpa racemosa* var *cylindracea* harvested at the various stations studied.

The chlorophyll a content was between the minimum for the thalli harvested from the Sbiaat station of a value of 8.82 ± 3.69 mg / g reaching the maximum in the thalli harvested from the Stidia station of a value of 17.58 ± 7.43 mg / g.

Concerning Chlorophyll b, the values were important and sometimes larger than those of Chlorophyll a, varying between the minimum value at the Sbiaat station for 7.36 ± 4.91 mg / g, from 13.02 ± 7, 76 mg / g for the Bousfer station and 10.89 ± 2.87 mg / g for Bosquet recording a relatively lower Chlorophyll b content than Chlorophyll a, unlike those of the other sites marking important values of Chlorophyll b compared to Chorophyll a reaching a maximum of 23.11 ± 17.56 mg / g for Stidia.

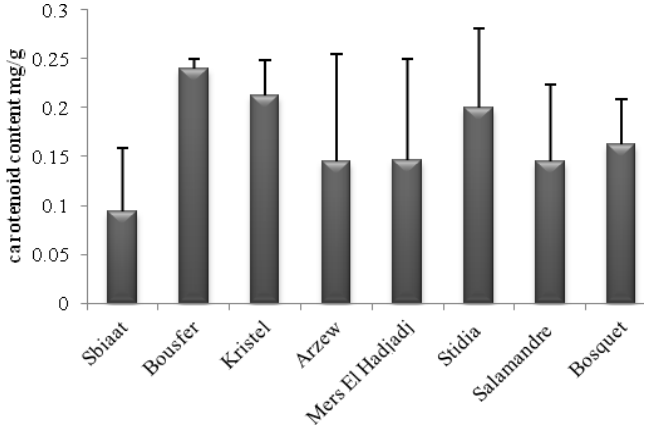

Fig. 4: Carotenoid content in the thalli of *Caulerpa racemosa* var *cylindracea* collected in the different stations studied.

The carotenoid pigments are less important and rare in the thalli of all the stations compared to the concentrations in Chlorophylls a, and b, with an interval of 0.09 ± 0.06 mg / g for the station of Sbiaat up to 0.24 ± 0.001 mg / g for Bousfer.

3. The content of mineral elements

Our results were compared with those of IAEA 413 (International Atomic Energy Agency., 2010)

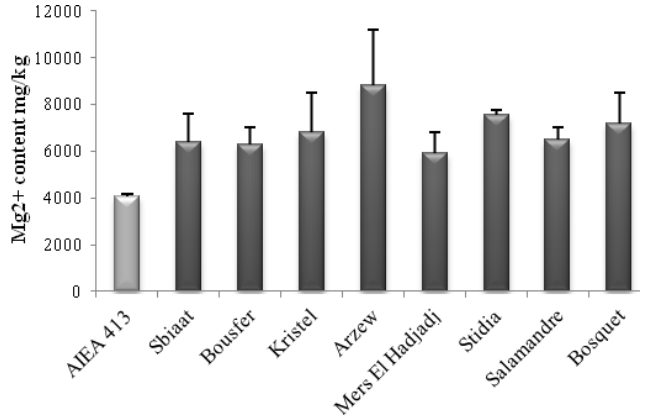

Fig. 5: Magnesium content in the thalli of *Caulerpa racemosa* var *cylindracea* collected in the different stations studied.

For magnesium, the values recorded were above that of the IAEA 413 (4058 ± 117 mg / kg), with an interval of 6253.87 ± 762 mg / kg for Bousfer up to 8793.24 ± 2409 mg / kg for Arzew. Values which were clearly high indicate the high content of these algae in this element (Mg^{2+}).

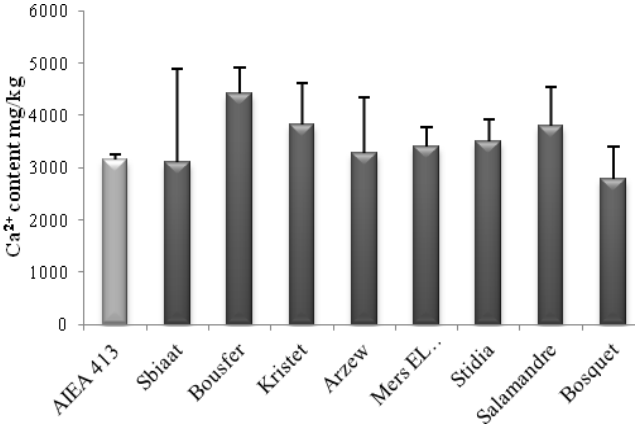

Fig. 6: Calcium content in the thalli of *Caulerpa racemosa* var *cylindracea* collected in the different stations studied.

For Calcium, the thalli obtained at the two sites Sbiaat and Bosquet marked slightly lower values compared to that of IAEA 413; (3143 ± 112 mg / kg) respectively 3093.99 ± 1796 mg / kg, and 2777.8 ± 635 mg / kg. For the other study sites, the calcium content was more or less significant reaching up to 4421.41 ± 504 mg / kg for Bousfer.

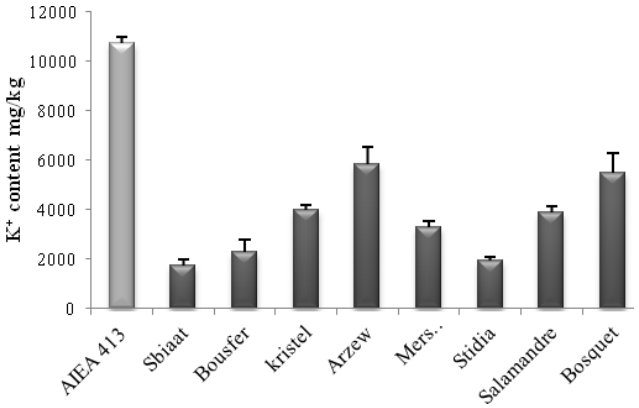

Fig. 7: Potassium content in the thalli of *Caulerpa racemosa* var *cylindracea* harvested in the different stations studied.

The potassium content was low for the thalli analyzed compared to the IAEA 413 (10740 ± 270 mg / kg). The marked values are around 1738.18 ± 253 mg / kg for Sbiaat up to 5831.47 ± 692 mg / kg for Arzew.

Unlike Potassium, the sodium content was at its maximum compared with that of IAEA 413 (375 ± 20 mg / kg) worth 11,417.87 ± 507 mg / kg for Sbiaat to have the maximum of 24,507, 35 ± 1550 mg / kg at the Grove level.

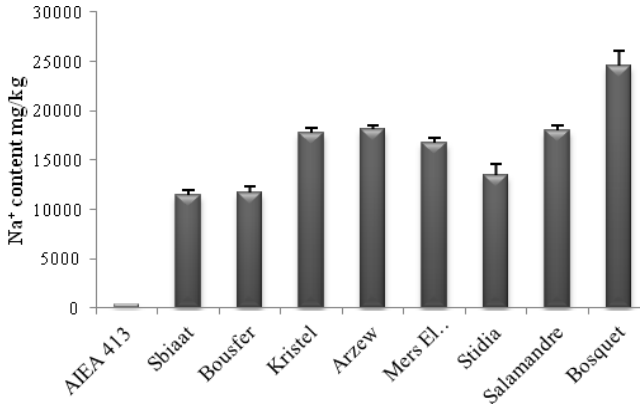

Fig. 8: Sodium content in the thalli of *Caulerpa racemosa* var *cylindracea* collected in the different stations studied.

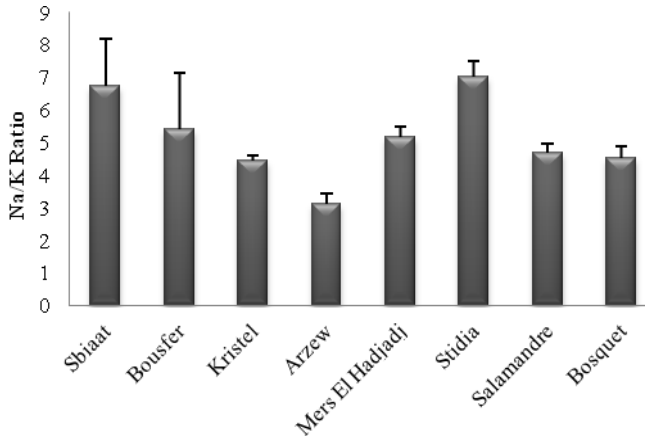

Fig. 9: Na / K ratio for the thalli of *Caulerpa racemosa* var *cylindracea* collected in the different stations studied.

The Na / K Ratio indicates significant values varying from 3.12 ± 0.3 for the Arzew station up to 6.72 ± 1.44 for Sbiaat and 7.01 ± 0.45 for Stidia this justifies the presence of the element Na in our samples in high concentration.

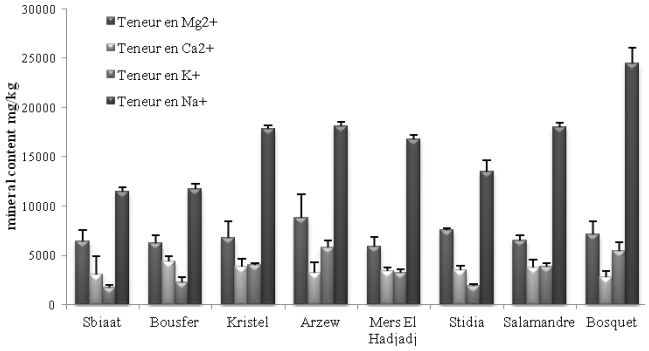

Fig. 10: Comparative mineral content in thalli of *Caulerpa racemosa* var *cylindracea* collected in the different stations studied.

All of our results allowed us to make a comparison between the content of different mineral elements in order to classify them according to the need of this alga in these minerals which are essential for its well being. These results allowed us to establish a very strong record in Sodium content in the first place for all the study sites, in the second place a high magnesium content which is also important for the individual and then the other two elements, also showing that Sodium and Potassium are in competition. For Calcium, despite its reduced content, it is in balance with the thresholds; Na> Mg> Ca> K.

Statistical analysis showed a highly significant difference ($p < 0.05$) between the contents of all the mineral elements for the thalli from the different stations studied.

Discussion

Macroalgae, or algae, grow on the seabed, rocky shores and other substrates and represent perennial multilayered vegetation growing photosynthetically (Singh & *et al.*, 2015). Algae are generally found in the intertidal region and undergo various chronic stresses, including desiccation, intense irradiance, ultraviolet radiation, salinity and submersion or exposure resulting from regular periodic tide rhythms (Kumar and Ralph 2017), which influence their productivity.

Our results show that the chlorophyll a and b content was important compared to the results of Suparna Roy, (2020) of the different species of *Caulerpa*; *C. racemosa* (Chlorophyll-a - 6.58 ± 0.17 mg / g dry weight; and Chlorophyll-b- 6.86 ± 0.11 mg / g dry weight), *C. racemosa* var. *macrophysa* (chlorophyll-a, - 6.94 ± 0.15 mg / g dry weight and Chlorophyll-b, - 9.12 ± 0.12 mg / g dry weight), *C. scalpelliformis* (Chlorophyll-a, - 7.30 ± 0.15 mg / g dry weight and Chlorophyll-b, - 8.58 ± 0.37 mg / g dry weight). and green algae *C. racemosa* var. *macrophysa* (9.12 ± 0.12 mg / g dry weight).

The carotenoid content of our species was also important compared to other algae species (Suparna Roy, 2020) The carotenoid content varied from a wide range, the red alga Gracilaria foliifera had the highest carotenoid content of 0.054 ± 0.03 mg / g dry weight, followed by 0.04 ± 0.002 mg / g dry weight as Carotenoid content of green algae *Caulerpa racemosa* var. *macrophysa*

According to the literature, the mineral content in algae generally varies between 8% and 40% (MacArtain & *et al.*, 2007) Most studies suffer from serious experimental limitations, including short duration of the study, small sample size and insufficient documentation of active ingredients. He there is relatively little literature describing the mineral content of macroalgae and microalgic foods (Cabrita & *et al.*, 2016)

Our study was based on the comparison between our results and the results obtained for the IAEA 413 (2010) as a reference for the maximum admissible dose for which our samples of *Caulerpa racemosa* exceeded the nutrient dose thresholds Na, Ca, Mg

The study by Kumar & *al* (2010) on three species of *Caulerpa* showed that the content of mineral elements was as follows; Na> K> Ca> Mg recording values for C reacmosa; (Na) 10.64 ± 0.29%> (K) 5.03 ± 0.32%> (Ca) 4.76 ± 0.87%> (Mg) 1.61 ± 0.15%.

The sodium potassium ratio (Na / K) was 2.12 ± 0.19%.

Conclusion

Caulerpa racemosa var *cylindracea*, the species introduced into the Mediterranean Sea, and the Algerian coast in particular, a species rich in minerals essential for plant life, in a way sodium, magnesium, calcium by exceeding the maximum admissible doses, which makes it hyperaccumulative nutritive matter determining the following equation Na> Mg> Ca> K. even in pigmentary matter, it is rich in chlorophyllian pigments, that can make it useful in the food or agricultural field.

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