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Seasonal variation in the growth responses of some chlorophytic algal flora of the Red Sea

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ABSTRACT

Seasonal variation in growth responses and antioxidant activities of four chlorophytic algal species, namely *Ulva lactuca*, *Enteromorpha flexuoca*, *Cladophora prolifera*, *Chaetomorpha linum* was investigated. Seasonal variation in the physico-chemical characteristics of water at the study site of the Red Sea was also determined. A significant variation was observed in water quality parameters in different seasons. All the algal species show higher accumulation of photosynthetic and accessory pigments in July and October and a significant decrease in January. Higher NPK content in all the four algal species was recorded in July, however, the contents were low in other months. Total protein contents were higher in July and October. Total carbohydrates in *U. lactuca* and *E. flexuoca* were significantly higher in July but in the other two species, *C. prolifera* and *C. linum*, maximum accumulation was observed in October. Antioxidant activities in all the species were most significant in January as compared to the other months. All the chlorphytic algae show prominent growth responses and antioxidant activities and are better adapted to changing climatic conditions. Due to their prompt responses even to minor changes in aquatic environment, they can be used as ecological indicators in coastal marine ecosystems.

Introduction

Changing climatic conditions such as nutrient availability, pH, temperature, light and precipitation affects vital plant processes (Tilman and Lehman, 2001). Marine algal flora makes a significant contribution in energy production, energy flow, remediation of pollutants and cycling of nutrients between aquatic and terrestrial ecosystems (Ansari et al., 2011a). Phytoplanktons are very sensitive to small changes in aquatic environments and are considered as strong indicators for the ecological health of an aquatic ecosystem (Xu et al., 2007; Ansari et al., 2017). Aquatic ecosystems are very rich in biomass and biodiversity (Swing, 2003; Sharma, 2005; Agarwal and Agarwal, 2007; Kim and Wijesekara, 2010; Ansari and Gill, 2017). Chlorophytic algae act as producers in marine ecosystems and are natural resource of food, fertilizers, fodder, edible fibres, antioxidants, vitamins, minerals, proteins, carbohydrates and other chemical compounds of human use (Figueroa et al., 2008; Cordell and White, 2013). Photosynthetic pigments play an important role in the growth and development of plants as they converts sun energy into carbohydrates through photosynthesis and further supply this energy to herbivores and carnivores in an ecosystem. Plant pigments are classified into photosynthetic pigments (chlorophyll) and other accessory pigments (carotenoids, phycoerythrin and phycocyanin). Carotenoids, phycoerythrin and phycocyanin help in capturing light energy for chlorophyll. Carotenoids also play an important role in antioxidant activities of the plants to cope with biotic and abiotic stress (Cabrita et al., 2010; Garcia-Rodriguez et al., 2010; Yang et al., 2011). Enzymatic and non-enzymatic antioxidant systems in plants are important for defense mechanisms against biotic or abiotic stresses (Yadav et al., 2014).

An undesirable change in ecological and environmental conditions alters the growth attributes of aquatic flora (Ansari et al., 2015; Ali and El-Magd, 2016; Xiao et al., 2016). Diversity and density of marine algal flora is influenced by various environmental factors of the aquatic ecosystems (Gabyshev and Gabysheva, 2016). Tabuk region of Saudi Arabia is known for its highly variable climate as the temperature, light, precipitation and wind velocity may vary from extremely low to extremely high. These varying environment conditions in different seasons of this region can lead to variations in growth responses of algal flora of the Red Sea (Ansari, 2016). The present research was conducted to explore the variation in growth attributes and antioxidants activities of

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some selected green algae namely *Ulva lactuca*, *Enteromorpha flexuoca*, *Cladophora prolifera*, *Chaetomorpha linum* from the Red Sea coast in response to the prevailing climatic conditions in four different seasons of Tabuk.

Materials and methods

Sample collection

The plant and water samples were collected on the 15th of January, April, July and October 2016 from Red Sea coast of Haql (29°17′9.9″ N 34°56′ 18.9″ E), Tabuk, Saudi Arabia. Water samples collected at the depth of 50 cm in plastic bottles of 1 L. The collected plant samples were washed thoroughly with sea water first, then with double distilled water and were stored in plastic jars of 1 L.

Physico-chemical characteristics of water

The water quality parameters such as pH, temperature, turbidity, dissolved oxygen, magnesium, calcium, silica, phosphates and nitrate were determined following APHA (2005).

Growth attributes

The collected chlorophytic algae were analyzed for the following parameters:

Photosynthetic and other accessory pigments

Chlorophyll and carotenoid contents were estimated spectrophotometrically following the method of Lichtenthaler and Buschmann (2001). Phycoerythrin and phycocyanin were estimated following Beer and Eshel (1985).

Nitrogen, phosphorus and potassium

The nitrogen and phosphorus contents were determined using the method of Lindner (1944) and Fiske and Subba-Row (1925), respectively. Potassium content was determined using flame photometry (Hald, 1947).

Total protein and carbohydrate

Total protein content was measured spectrophotometrically according to Bradford (1976) and total carbohydrate was determined following the method (Anthrone method) of Hedge and Hofreitter (1962).

Proline

Proline was determined spectrophotometrically following Bates et al. (1973).

Antioxidant activities (Superoxide dismutase, catalase and peroxidase)

The supernatant of plant tissues was prepared for the assay of enzyme activities by homogenizing three volumes (w/v) of anicecold extraction buffer (50 mMTris–HCl, pH 7.8, 1 mM EDTA, 1 mM MgCl2and 1.5% (w/w) polyvinylpyrrolidone) and centrifugation of homogenate at 15,000*g* for 20 min at 4 °C. Activity of superoxide dismutase (E.C. 1.15.1.1) was determined following Beauchamp and Fridovich (1971). Catalase activity (E.C. 1.11.1.6) determined by the method of Cakmak and Marschner (1992). Peroxidase activity (E.C. 1.11.1.7) detected following Upadhyaya et al. (1985).

Statistical analysis

The data (mean of three replicates) were analyzed statistically for its significance using SPSS-17 statistical software (SPSS Inc., Chicago, IL, USA). The data were subjected to a one way ANOVA with least significance difference (LSD) tests at a significance level of ($p < 0.05$).

Results

Physico-chemical characteristics of water

Table 1 shows a significant variation in water quality parameters of the Red Sea in different seasons. pH in all the seasons were alkaline and in the range of 8.1–8.5. Lowest water temperature of 5 °C was recorded in January and highest 19 °C in July. Water was more turbid in the month of July as compared to other seasons, water samples were very clear in January. Dissolved oxygen contents were highest at 6.54 mg/l in October and lowest at 4.84 mg/l in July. Dissolved nutrients i.e. Magnesium, Calcium, Phosphates and Nitrates were significantly increased in July as compared to the other seasons. Silica contents in water also showed similar patterns (Table 1).

Photosynthetic and other accessory pigments

Table 2 shows significant variation photosynthetic and accessory pigments of the four selected chlorophytic algae of the Red Sea in different seasons. Chlorophyll contents in *U. lactuca* and *C. prolifera* show a significant increase in July whereas in *E. flexuoca* and *C. linum* in April and October, respectively. A significantly higher accumulation of phycoerythrin in *E. flexuoca*, *C. prolifera* and *C. linum* was recorded in October whereas in *U. lactuca* they were higher in July. Phycocyanin and carotenoids shows a significant increase in all the four selected species of green algae in July. Chlorophyll, phycoerythrin, phycocyanin and carotenoids pigments in all the species shows a significant decrease in January.

Table 1
Seasonal variation in the physico-chemical characteristics of water at the study site of the Red Sea.

Parameters	Jan	Apr	Jul	Oct	LSD at 5%
pH	8.4 ± 0.4	8.2 ± 0.2	8.1 ± 0.2	8.5 ± 0.3	0.2
Temperature (°C)	5 ± 0.5	15 ± 1	19 ± 2	17 ± 2	2
Turbidity (NTU)	10 ± 2	13 ± 1	16 ± 1	12 ± 2	1.5
Dissolved oxygen (mg/l)	4.94 ± 1.0	5.64 ± 1.02	4.85 ± 1.1	6.54 ± 0.95	1.4
Magnesium (mg/l)	222 ± 8.6	232 ± 9.2	262 ± 8.8	245 ± 10.5	9.2
Calcium (mg/l)	77.9 ± 8.8	84.8 ± 9.5	145.7 ± 12.6	91.5 ± 10.0	7.5
SiO_3 (μg/l)	6.6 ± 1.4	7.2 ± 1.0	7.1 ± 1.2	6.2 ± 1.56	NS
Phosphates (μg/l)	20.48 ± 1.54	25.8 ± 1.28	35.45 ± 3.12	16.61 ± 3.06	2.45
Nitrates (μg/l)	44.81 ± 4.22	56.5 ± 7.45	85.9 ± 4.36	38.85 ± 3.47	3.82

DATA = MEAN ± SD, LSD = Least Significant Difference at 5% probability.

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