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Seasonality affects dinitrogen fixation associated with two common macroalgae from a coral reef in the northern Red Sea

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ABSTRACT: Nitrogen (N) is often a limiting nutrient for primary production in coral reef ecosystems. In this context, dinitrogen (N_2)-fixing prokaryotes (diazotrophs) associated with benthic primary producers can relieve N limitation. Macroalgae are key reef players that are generally able to rapidly uptake dissolved inorganic nutrients. They may thus particularly benefit from the activity of associated diazotrophs. With this rationale, this study investigated N_2 fixation activity and net primary production associated with 2 dominant coral reef macroalgae (the green algal genus *Caulerpa* and the brown algal genus *Lobophora*) during all 4 seasons in a fringing northern Red Sea reef using the acetylene using the acetylene reduction assay and oxygen production and consumption measurements. Both macroalgae exhibited associated N_2 fixation activity during all seasons with lowest activity in winter and significantly higher activity (1 and 2 orders of magnitude increase for *Lobophora* and *Caulerpa*, respectively) during the nutrient-depleted summer, while net primary production for both macroalgae remained relatively constant over all 4 seasons. Primary production rates of the macroalgae were comparable to corals from the same area on a yearly average. Conversely, average N_2 fixation rates of both macroalgae were approximately 5-fold higher than rates reported for hard corals that were incubated in parallel experiments. These results indicate that macroalgae can capitalize on higher inputs of N from epibiotic diazotrophs, which in turn could prove an ecological advantage when competing for space with corals.

KEY WORDS: Gulf of Aqaba · Acetylene reduction · Primary production · Macroalgae · Dinitrogen fixation

INTRODUCTION

Coral reefs are systems that exhibit notably high primary production despite being surrounded by oligotrophic waters (Odum & Odum 1955). Due to the scarcity of bioavailable nutrients, benthic organisms such as hard and soft corals have evolved an effective mutualistic symbiosis with single-celled dinoflagellates of the genus *Symbiodinium* (also known as zooxanthellae) for maintaining efficient uptake, recycling and conservation of (in)organic carbon (C), phosphorus (P) and nitrogen (N) (Davy et al. 2012, Kopp et al. 2013, Ferrier-Pagès et al. 2016). In this biogeochemical cycling of nutrients, N is often considered the limiting factor that controls primary productivity (i.e. the fixation of inorganic C through photosynthesis), and is therefore an essential macronutrient for zooxanthellae (Falkowski 1997, Wang & Douglas 1999). Uptake of

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