Production of nama seaweed (*Caulerpa* spp.) in an experimental lagoon cultivation setting and land-based system – Influence of cultivation depth and nutrient load on growth and morphology

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1: Nama seaweed in the lagoon of Kavewa island


2: Nama harvesting women from Kavewa island picking up fresh nama


3: Cleaned nama fronds from the market in Suva

Background

Edible *Caulerpa* seaweeds are traditionally hand-harvested from reefs and shallow waters in Fiji (Fig. 1 and 2) and provide an important source of income for women in coastal communities [1]. Demand for these so-called "nama" seaweeds exceeds current supply, and intensive harvesting in fragile island ecosystems may lead to overexploitation and associated biomass loss [4]. Sustainable aquaculture of nama offers a promising alternative to ensure long-term production of valuable biomass while minimizing pressure on natural ecosystems. In Fiji, nama quality is strongly linked to morphology, with dark green coloration, thick fronds, and high ramuli density being the most important quality attributes (Fig. 3). As nama morphology is highly affected by its cultivation environment, any cultivation approach should not only focus on rapid growth but also desirable morphological characteristics [6]. In Fiji, the main morphological quality characteristics are deep green and thick fronds, densely packed with ramuli.

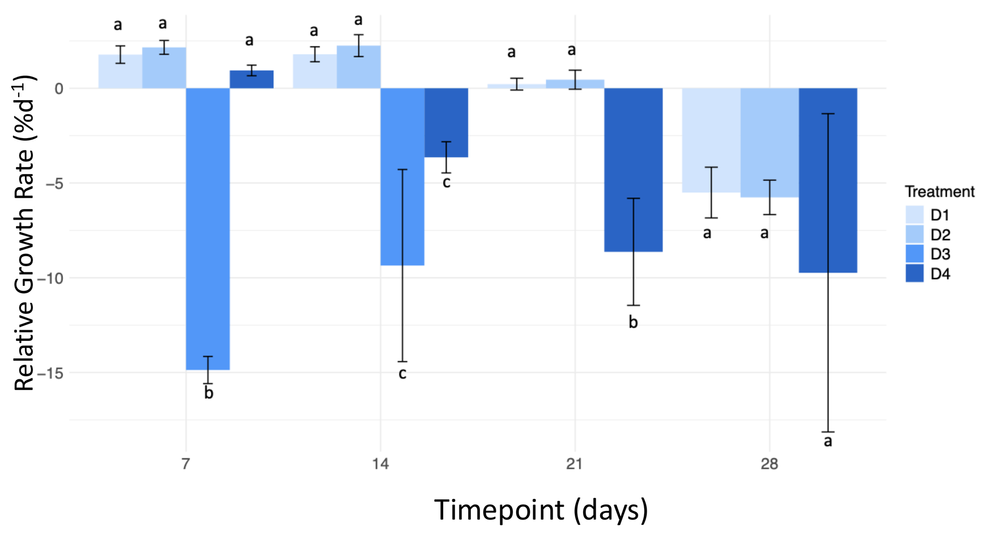
In this study, two *Caulerpa* farming approaches were evaluated in Fiji. A lagoon cultivation at four different depths (D1–D4) in the lagoon of Kavewa island (Fig. 4) and a land-based tank system with NPK fertilizer addition (TN) and an unfertilized control (TC) at the Galoa Fishery Station (Fig. 5). Nama was cultivated on 0.25 × 0.25 m double-layer trays with three replicates per treatment and a stocking density of 200 g per tray. Photosynthetically active radiation and temperature were monitored using HOBO data loggers. Relative growth rate (RGR) was calculated at the beginning and end of each experiment. In the lagoon-based experiment, the influence of cultivation depth on the key morphological traits was assessed, while in the land-based experiment, the effects of nutrient availability from fertilizer addition on these traits were examined. Morphological characteristics were used as quality indicators and compared with nama samples from commercial markets in Fiji to establish a quality benchmark.

Results

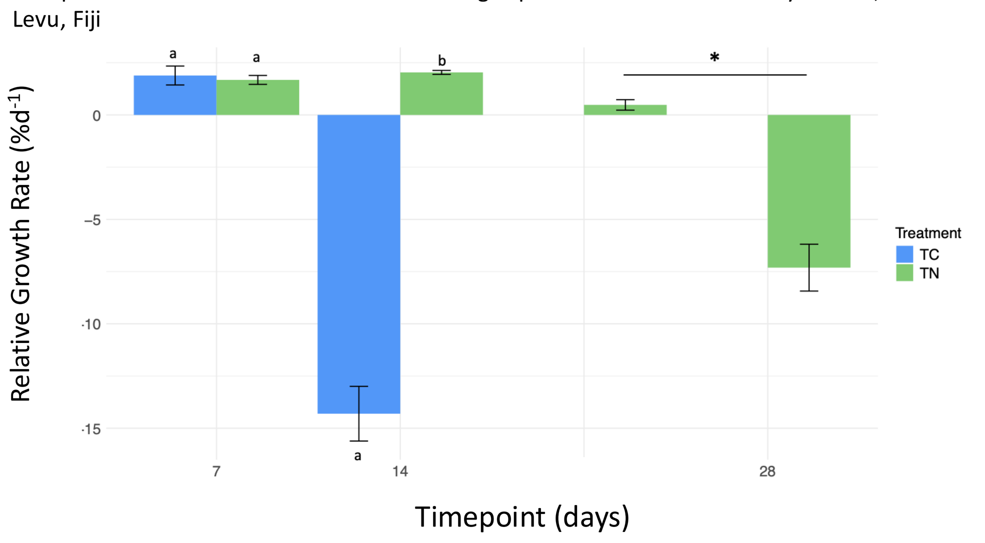
In lagoon cultivation, nama showed higher RGR in shallower depths, reaching 2.16 ± 0.58 % day^{-1} during the first two weeks (Fig. 6). Morphological traits did not differ significantly among depths. Grazing by fish was observed in the deeper treatments, resulting in biomass loss. Across all depths, nama biomass bleached and died off after a maximum of two weeks (Fig. 8).
In the land-based experiment, the fertilized TN and unfertilized control treatment TC, also showed positive RGR. Shortly before week two, nama in TC started bleaching and died off, similar to the lagoon experiment observations. In contrast, the NPK-fertilized treatment TN maintained positive growth and achieved the highest RGR 2.03 ± 0.01 % day^{-1} after two weeks (Fig. 7). Morphologically, nama from the TN treatment exhibited a darker green coloration but fronds were thin and sparsely covered with ramuli, resulting in lower quality compared to market-sourced nama biomass (Fig. 9).


4: Experimental site for the lagoon farming experiment at Kavewa island, Vanua Levu, Fiji


5: Experimental site for the lsnd based farming experiment the Galoa Fishery Station, Viti Levu, Fiji



6: Daily relative growth rate RGR (% day^{-1}) for each treatment D1-D4 measured in weekly intervals, given as mean ± standard deviation. Small letters in both figures indicate the Dunns test post-hoc results where significant differences between treatments are displayed by non-matching letters and matching letters correspond to no significant differences.

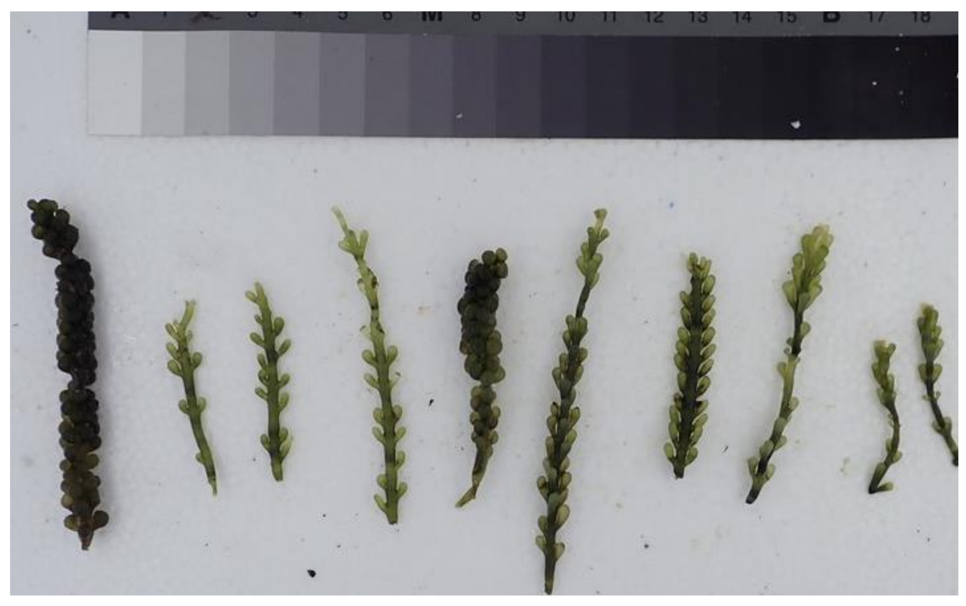


7: Daily relative growth rate RGR (% day^{-1}) for both treatments TC = Tray Control and TN =Tray Nutrients measured in weekly intervals, given as mean ± standard deviation. No biomass was available for treatment TC, resulting in missing values. Small letters indicate the Dunns test post-hoc results where significant differences between treatments are displayed by non-matching letters and matching letters correspond to no significant differences.

Discussion

Bleaching and mortality of nama may have resulted from nutrient limitation and associated reduced chlorophyll-a synthesis [5]. Cultivation on trays may offer restricted nutrient uptake from the oligotrophic water column, suggesting that nama either relies on nutrients from benthic sediment reservoirs or requires additional nutrient supplementation in the surrounding water for sustained growth and high-quality biomass production [2]. The pronounced morphological changes observed under nutrient supplementation suggest that the form or concentration of supplied nitrogen and phosphorus may not have been sufficient, underlining the morphological plasticity of nama under changing environmental conditions [3].


8: Bleached and disintegrated nama fronds from the lagoon cultivation experiment after week two


9: Nama fronds from the TN treatment of the land-based experiment, exhibiting dark green coloration but thin fronds and and overall poor ramuli density

Conclusion

The availability of sufficient nutrients, as well as their appropriate concentration and composition, appears to be the key factor for successful nama cultivation when grown on trays without contact with sediment. Under these conditions, nama may represent a promising candidate for future co-cultivation with other food or feed organisms

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