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Updated hatchery and cultivation methods for the Atlantic rhodophyte *Palmaria palmata*

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The red seaweed *Palmaria palmata*, also known as dulse, is highly demanded as a snack food and show promising applications in multiple products [1] why the interest of its cultivation is increasing in Europe. Despite two decades of cultivation research, inadequate hatchery method has halted the development of large-scale cultivation [1,2]. Here, we present the results of a 4-year PhD collaborate project with Danish and Norwegian research institutes with innovative methods and new insights into the cultivation steps including i) the induction of tetrasporophytic spore formation, ii) efficient spore-use for seeding substrates, iii) seedling growth, and iv) different long-line cultivation configurations to optimize harvest yield in Danish waters.

Results: i) We report the content of selected polyamines in ripe fertile sporophytes compared to non-fertile individuals, indicating the potential involvement of biogenetic amines in sporogenesis. ii) Agitation significantly promoted spore release. Likewise, spore dispersal and settlement (seeding quality) was successful by using vertical seeding tanks, hemispherical water agitation and flow-through conditions tested with different amounts of spore-donor and a new seeding method for *P. palmata*. Net substrates were sufficiently seeded (9 seedlings cm^{-1}) by using three amounts of spore donor (5, 10, 15 g FW sori to seed ~48 m substrate) with no significant difference in seeding density after 32 days in nursery. In addition, collecting and in effluent water and germinating the spores was demonstrated as a new method to perform *Palmaria palmata* seeding to improve spore use efficiency and enabled a higher amount of growth substrate to be seeded per unit spore donor, compared to conventionally applied hatchery protocols. This secondary propagule seeding method is denoted the **GMA**-seeding method, based on **G**ermination, **M**aceration, and **A**gitation steps. After germinating into gametophytes, the ability of females and males to re-attach on rope substrates within 3-10 days in agitated conditions was possible until day 39, but not day 240, after spore release. Nursing spore-seeded nets for longer time promoted bigger seedlings at deployment, which showed to benefit harvest yield and quality when cultivating dulse in eutrophied waters. This project provide new insights into induction of fertility of this demanded seaweed species and provide an update on its cultivation methods for *P. palmata,* which is crucial to promote its large-scale and cost-effective production.

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