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Artificial seed production and cultivation of the edible brown alga, *Sargassum fulvellum* (Turner) C. Agardh: Developing a new species for seaweed cultivation in Korea

Eun Kyoung Hwang[1,*], Chan Sun Park[2] & Jae Min Baek[1]
[1]*Seaweed Research Center, National Fisheries Research and Development Institute, Mokpo 530–831, Korea;*
[2]*Department of Marine Resources, Mokpo National University, Jeonnam 534–729, Korea*

*Author for correspondence: e-mail: ekhwang@momaf.go.kr/ekhwang@hotmail.com; fax: +82-61-285-1949

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Abstract

Sargassum fulvellum is a brown alga recently introduced to the seaweed cultivation industry in Korea. There is current interest in the commercial scale of aquaculture of this species. For the artificial seeding and cultivation of this alga, growth and maturation were investigated from September 2002 to August 2003. Indoor culture experiments for maturation induction were also conducted at temperatures of 5, 10, 15, 20 and 25 °C and irradiances of 20, 50, 80 and 100 μmol photons m^{-2} s^{-1} under 16:8 h (L:D) photoperiod. Within a given culture test range, higher temperature and irradiance levels favoured the maturation of receptacles in *S. fulvellum*. Using temperature and irradiance control for thalli, artificial seed production of this species could be done one month earlier than thalli matured in nature. Under natural condition, receptacle formation of the plants began in February, and the eggs were released from March to April. For mature thalli of 200 g wet wt., artificial seeding was complete enough for attachment on seed strings of 100 m. Mean production obtained from the artificial seeding technique *in situ* was 3.0 kg wet wt m^{-1} of culture rope during the cultivation period.

Introduction

The perennial brown alga *Sargassum fulvellum* (Turner) C. Agardh has a wide distribution from the south to the eastern coasts of Korea. This species usually grows at depths of 3–5 m or more. There are 28 species of *Sargassum* species reported in Korea (Lee & Kang, 2002). Among them, *S. fulvellum* is the common edible *Sargassum* species used as a seaweed salad. In the local Korean market, the retail price of naturally collected *S. fulvellum* is US$ 2.3–3.8 kg^{-1} fresh wt.; that of *Porphyra* and *Undaria* is 0.5–1.5 and 0.07–0.1 kg^{-1} fresh wt., respectively. The seaweed cultivation industry in Korea depends on a few species such as *Porphyra, Undaria, Laminaria* and *Hizikia* (Sohn, 1993, 1998). *S. fulvellum* can be a potential seaweed species for economic seaweed cultivation by fishermen in Korea. Since the demand for *S. fulvellum* is likely to remain high in the future, it is necessary to develop mariculture. Furthermore, *Sargassum* beds play important ecological roles in the coastal ecosystem due to their large biomass and high productivity. These beds provide nursery areas to commercially important fish species and help to preserve environmental conditions. Therefore, considerable information has been accumulated on their growth, maturation period and cultivation techniques from ecological and industrial viewpoints.

This is the first report on artificial seeding and cultivation of *S. fulvellum*. We report here the growth and maturation period of *S. fulvellum*, and artificial seeding and culture conditions for its commercial cultivation.

Materials and methods

Plants were collected monthly at Wando (34°18′N, 126°45′E) on the southwestern coast of Korea from September 2002 to August 2003. Three 50 × 50 cm quadrats were randomly placed, and all thalli inside the quadrats were collected and carried to the laboratory. Once in the laboratory, thalli were cleaned of epiphytes and rinsed with filtered seawater. All the thalli were measured in length and weighed. The water temperature was measured at the sampling site. For indoor culture experiments, reproductive plants were transported to the laboratory immediately after collection in February 2003. The plants were rinsed in sterile, filtered seawater and the receptacles excised. These were treated by immersion in 1% Betadine (povidone iodine) solution for a few seconds. They were then incubated at 15 ± 0.5 °C in an antibiotic mixture solution (Guillard, 1968) for a day. After being cleaned, the receptacles were cultured in petri dishes (30 explants in each) with 20 ml of PESI culture medium. Water temperatures of 5, 10, 15, 20 and 25 °C were used for the maturation of receptacles. Irradiances were measured on a LI-1000 Data Logger (Li-Cor, U.S.A.) as 20, 50, 80 and 100 μmol photons m^{-2} s^{-1} at the surface on the sterilized petri dishes. In all the cultures, multi-room chamber incubators (HB-302M-4, Hanbaek Co., Korea) were used for the photoperiodic control of 16:8 h (L:D). Total length was expressed as the mean values of the plants in each treatment. Maturation was determined as the percentage of explants in each treatment showing germling release, under microscopic observation ($n = 30$ in each treatment).

The collected thalli were kept and attached on 150 cm lengths of polyvinyl chloride (PVC) pipes for 2 months in a square concrete tank containing 2 tons of seawater, which was continuously aerated. The PVC pipes help to sink the thalli to bottom of the tank so that the thalli cultured under water are not exposed to the air. It was also easy to handle the thalli and select those mature enough to have embryos.

Mature thalli were thinned out from the PVC pipes and then moved to plastic dishes (50 cm in diameter, 20 cm in depth), to gather dense embryo solutions by rubbing the mature thalli which had embryos in their receptacles. The liberated embryos that sunk onto the bottom of the plastic dishes were collected by net (ca. 300–500 μm in mesh size), and washed several times with fresh filtered seawater. As a seeding material for the embryos, PVC frames (ca. 35 cm height × 45 cm width, holding a total length of 100 m of string made of mixed nylon and polypropylene fibers) were used for *Undaria* cultivation, and the collected embryos in suspension were attached onto the seed frames with a paintbrush. At the time of the attachment, all seed fiber had to be dried before attaching the embryos because the dried fiber absorbed the water containing the embryos. Embryos may have been held by the absorption force of the string fiber until they grew their holdfast on the substratum. Seedlings of *S. fulvellum* were reared in an indoor tank for 60 days until they were up to 10–15 mm in length. The tank used for the seedling culture was 80 cm wide, 7 m long and 70 cm deep. Fresh seawater and air were continuously supplied, through a pipe, to the tank. Water temperature was not controlled due to the influx of natural seawater. Illumination was regulated with a shading sheet, to about 60–80 μmol photons m^{-2} s^{-1} (on the water surface, at noon on fine days). During the seeding and culture, the length and number of fronds on the seed string and number of laterals were measured once a week. After one month of tank culture, seedlings were transferred to the nursery culture ground in Wando for one month. After that, culture at sea was carried out using a long-line system, described by Sohn and Kain (1989). A 100 m line (10 mm in diameter) was used with coiled seed strings (3 mm diameter, 50 mm length) every 10 cm. The main culture line was held at 1 m depth, using plastic buoys. Culture ropes were periodically cleaned of fouling. Biological variables such as length of thalli and biomass per culture rope were measured monthly during the culture season.

Results

Water temperature varied from 7.1 to 23.6 °C during the experiment (Figure 1). Maximum water temperature was recorded in September 2002, and the minimum in February 2003. *Sargassum* started to grow when the temperature decreased below 23 °C in September. Growth of *Sargassum* thalli was observed from September in the natural habitat. From February, growth in length of the stipe increased rapidly. It reached a mean maximum of 104.6 ± 20.7 cm in the middle of March, and then started to decrease. In May, main axes were bleached and only holdfast parts were left on the substratum. In nature, receptacle formation was observed from February to April when water temperature was 7.1–12.8°C. The peak period for egg release from female receptacles was from March to April.